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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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SCIENCE ABSTRACTS.

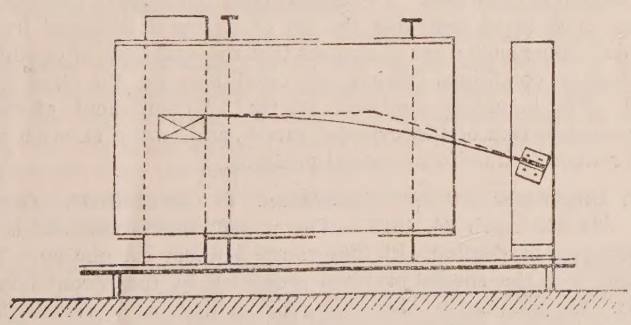
Section A.—PHYSICS.

JUNE 1918.

GENERAL PHYSICS.

593. *Electrical Instrument for recording Sea-water Salinity.* **E. E. Weibel** and **A. L. Thuras.** (Washington Acad. Sci., J. 8. pp. 145–153, March 19, 1918.)—A Wheatstone bridge method is used, a sealed cell containing sea-water of known average salinity being balanced against another cell which is open and has flowing throughout it the sea-water to be measured. The two cells are placed in a uniform temperature bath. The indicator is an a.c. galvanometer. L. H. W.

594. *Measurement of Impulsive Forces.* **L. Schlussel.** (Comptes Rendus, 166. pp. 456–459, March 18, 1918.)—Describes a method for the measurement of impulsive forces by means of a heavy mass carrying a pen



which touches lightly a moving band of paper as shown in the Fig. The line described on the paper indicates the relative motion between the mass and the support, *i.e.* the amount of the applied impulsive force. J. W. T. W.

595. *The Linear Dimensions of Density Variations.* **L. S. Ornstein** and **F. Zernike.** (Phys. Zeits. 19. pp. 134–137, April 1, 1918.)—M. v. Laue has recently published a paper on temperature and density variations in which he states that there is a complete misconception of the facts when the literature is consulted for a calculation of the linear dimensions of density variations. The present authors having already published a paper on this subject [see Abs. 881 (1916)], they now give a survey of their theoretical

considerations and an abridged description of their method for obtaining a suitable formula. The case at the critical point is carefully examined, since small forces exercise a very appreciable influence on the density.

The paper is mathematical throughout. H. H. H.

596. *Stress-strain Relations in Crystalline Cylinders.* **P. W. Bridgman.** (Am. J. Sci. 45. pp. 269–280, April, 1918.)—In a preceding paper the author has made experimental examination of the manner of failure under high pressure of cavities in various materials of geological interest. For simplification a number of the specimens were cut from single crystals and made in the form of circular cylinders, pierced axially with circular holes concentric with the outer surface. It appeared on assembling the results, that the mathematical problem of the elastic behaviour of crystalline material had never been discussed. The author has now obtained an approximate solution, and the results for several systems of crystals are here recorded. In the mathematical analysis are two leading ideas. An exact solution was found to be out of the question, as, in order to compute the numerical coefficients it was necessary to solve a system of infinitely many linear algebraic equations. An approximate solution, however, was obtained by the device of varying the elastic constants, allowing them to approach infinitely close to those of an isotropic body, and finding the infinitesimal terms which must in consequence be added to the well-known solution for an isotropic body. The second idea was to discover the nature of the terms present by considering the symmetry relations of the crystals. This saved an enormous amount of time, for if an ordinary series were assumed for the solution, most of the coefficients would be found to be zero. In the paper the solution is obtained to first-order terms for cubic and tetragonal crystals, and to second-order terms for trigonal crystals. For the latter the solution has been carried through numerically in the case of quartz, which was one of the materials experimented upon, and the closeness of the approximation is discussed. The mathematical procedure consists in finding such a set of displacements that the set of strains determined by them will in turn determine such a set of stresses that the equations of equilibrium and the boundary conditions (which are conditions on the stresses) shall be satisfied. The boundary conditions are that all components of stress on the inner curved surface of the cylinder vanish, and on the external surface the stresses reduce to a uniform normal pressure. H. H. H.

597. *Long-range Artillery Calculation.* **G. Greenhill.** (Engineering 105. pp. 464–465, April 26, 1918.)—The paper commences with a survey of past procedure in dealing with long-range artillery calculation. The author then deals with the special problem presented by the recent bombardment of Paris. He assumes a shot flying horizontally at a velocity of 2640 ft. per sec. and 20 miles high. At this height, and for a considerable distance lower, air-resistance may be ignored in the absence of any appreciable atmosphere, so the calculation of the advance of the shot on the parabolic theory is made while it has risen or fallen, say, 15 miles before or after and is still some 5 miles high above the ground. The time occupied in each of these movements will be about 70 secs., so that the total horizontal advance is 70 miles. This parabolic trajectory may be supposed to be raised on stilts 5 miles high, and the initial and final parts of the trajectory in resisting air treated separately. The sweep of the curve must be flatter than the parabola and outside at the gun end, but inside and more curved when the shot is falling. An initial velocity is deduced in the region of 4000

per sec. The uncertainty in all these calculations of long-range fire is the estimate of air-density in the upper strata of the atmosphere, discussed as a whole. Two assumptions are employed of this constitution, between which the true density of the air may be supposed to lie : (1) isothermal equilibrium ; (2) convective equilibrium. These are discussed and the conclusion is drawn that the convective theory should not be employed beyond a limited height in the atmosphere. On the former theory there will still be a small but appreciable resistance at 10–20 miles high. The author concludes that if these artillery ranges go on increasing, the old parabolic theory of Galileo with a gravity in parallel lines will have to be abandoned, and the shot treated as an independent planet or satellite, which, in the absence of air-resistance, would move in an elliptic orbit about the centre of the earth as focus.

H. H. Ho.

598. *Graphical Solution for High-angle Fire.* **A. N. Whitehead.** (Roy. Soc., Proc. 94. pp. 301–307, May 1, 1918.)—The point of the method described is the reduction of the calculation of the path of a shell in high-angle fire to processes which can be either graphically constructed or calculated, once and for all, the results applying to all trajectories and to shells of any ballistic constant. It is assumed that the law of resistance $R(v)$ is largely empirical, and is not to be reduced to any neat mathematical formula. Furthermore the variation of the density of the atmosphere is taken account of, and its dependence on the height is assumed to be given by some empirical formula. The graphical method evolved utilises five curves, which are the same for all projectiles and all trajectories, and which can be reproduced once for all on suitably arranged sheets of the proper dimensions.

H. H. Ho.

599. *Long Columns carrying Distributed Loads.* **A. Morley.** (Engineering, 104. pp. 565–567, Nov. 30, 1917.)

600. *On a New Gyroscopic Phenomenon.* **E. E. T. Hinde** [with a Note by A. Gray]. (Roy. Soc., Proc. 94. pp. 218–222, March 1, 1918.)—Describes the rising action noticed when a gyroscopic top, having one end of its spinning axis shaped like an eyebolt, was so placed that a vertical rod passed through the eye. The ring is of internal diam. such that whilst a loose fit on the rod when the top's axis is horizontal, it binds on the rod when the axis assumes a small inclination from the horizontal position.

In a supplementary note Gray explains the action as being due to want of balance of the gyroscope wheel.

L. H. W.

601. *Theory of Water-hammer in Conduits.* **C. F. Mancini.** (N. Cimento, 14. pp. 143–184, Oct., 1917.)—Discusses the influence on this effect of the time of opening or closing the outlet in a length of pipe through which water is flowing under a head. The results previously obtained by Allievi and others [see Abs. 1245 (1904), 1682–4 (1905), and Abs. 922 (1913)] are considered. The paper is divided into (i) a discussion of the theory of propagation of the elastic wave, and (ii) the application of this theory to the determination of the max. pressure at the outlet. The effect of the elasticity is to diminish the pressure in the case of rapid closing, and to increase the pressure in the case of slow closing, *i.e.* to diminish the effect of the speed of closing the outlet.

J. W. T. W.

602. *Stream Lines and Level Surfaces of a Liquid having Two-dimensional Flow from a Vessel.* **O. Tumlirz.** (Akad. Wiss. Wien, Ber. 126. 3. pp. 347–

370, 1917.)—This paper is mathematical throughout, and should be consulted in its entirety. Three figures and tables of data are included. H. H. Ho.

603. *Whirling and Whip of a Revolving Shaft.* **G. Greenhill.** (Engineering, 105. pp. 273–274, March 15; 387–390, April 12, and pp. 415–417, April 19, 1918.)—The article is of a mathematical nature and unsuitable for abstracting; it contains a digression on Units. L. H. W.

604. *The Spinning-top in Harness.* **G. Greenhill.** (Engineering, 105. p. 553, May 17, 1918. Paper read before the Roy. Inst., May, 1918.)

605. *On the Theory of Gravitation.* **H. Weyl.** (Ann. d. Physik, 54. 2. pp. 117–145, Feb. 15, 1918.)—The paper is divided into two parts (A and B). In A, additions to the general theory are considered in three sub-sections, viz. (1) Application of an Hamiltonian Principle to the solution of such problems as can be treated in our present defective knowledge of matter. (2) The energy impulse is in general the expression satisfied by the Hamiltonian Principle for such variations in state dimensions as are produced by an infinitesinal deformation of the 4-dimensional universe, when the state dimensions are included in the deformation. (3) Discussion of the connection between theory and observation. Application of Fermat's Principle for the shortest path of light rays in the static gravitational field, and of an analogous principle for the orbit of a charged mass-point under the influence of gravitation and electricity.

In B, the theory of the statical axially symmetrical field is considered in 3 sub-sections, viz. (4) Simple application of the Schwarzschild solution for a mass point, and transformation to another important coordinate system. Electrostatic and gravitational field of a charged mass-point. (5) By the construction of a suitable coordinate system termed "canonical cylinder coordinates," it has been possible to evaluate the field of masses at rest as simply as on the Newtonian theory; between the solutions of Newton and Einstein there exists a general relationship expressible by elementary functions. (6) A corresponding solution is found to hold good for the electrostatic and the gravitational field of rotationally symmetrically-distributed charges. Deviations from the classical theory are exceedingly small in the case of atomic measurements. H. H. Ho.

606. *On Gravitational Waves.* **A Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 8. pp. 154–167, 1918.)—The important question of how the propagation of the gravitational field takes place has already been treated by the author, but as his presentation lacked clarity, and, in addition, was complicated by regrettable arithmetical errors, he now reopens the question. Section 1 deals with the solution of the approximate equations of the gravitational field under retarded potential. Section 2 examines the energy components of the field. Section 3 investigates plane gravitational waves. Section 4 deals with the emission of gravitational waves by mechanical systems. Section 5 examines the action of gravitational waves on mechanical systems. Section 6 gives an answer to an objection raised by Levi-Civita. H. H. Ho.

607. *Critical Examination of De Sitter's Solution of the Gravitational Equations.* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 14. pp. 270–272, 1918.)—De Sitter, who has recently [see Abs. 10, 11, 291 (1917)] made a very critical study of the general theory of relativity, has now put forward a solution of the gravitational equations, which, in his opinion, may afford

insight into the metric structure of the universe. This solution of the field equations : $G_{\mu\nu} - \lambda g_{\mu\nu} = -kT_{\mu\nu} + \frac{1}{2} g_{\mu\nu} kT$, runs $T_{\mu\nu} = 0$ (for all indices), $ds^2 = -dr^2 - R \sin^2 (r/R)[d\psi^2 + \sin^2\psi d\theta^2] + \cos^2(r/R)c^2dt^2$, where r, ψ, θ, t are coordinates. The present author here presents a strong mathematical argument against the validity of this solution and the conclusions drawn therefrom. He shows that De Sitter's system corresponds to a universe whose matter is concentrated entirely in the surface $r = \pi/2R$. H. H. Ho.

608. *Derivation of Gravitational Field Equations.* **F. Jung.** (Phys. Zeits. 19. pp. 61–66, Feb. 15, 1918.)—A highly mathematical paper dealing with the application of relativity theory to gravitation as recently introduced by Einstein. [See Abs. 853 (1916).] E. H. B.

609. *Brownian Movements.* **W. D. Bancroft.** (J. Phys. Chem. 22. pp. 273–299, April, 1918.)—After a discussion of the work carried out by various investigators the author concludes that the safe ground to take is : that the Brownian movements are due to the incessant movements of the molecules of the fluid ; that the Brownian movements tend to make finely-divided, suspended particles distribute themselves uniformly throughout the liquid ; that the uniform distribution is affected by the force of gravity as in the case of a gas ; and that the Brownian movements, though causing diffusion, give rise to no appreciable osmotic pressure.

Very finely divided particles (less than 0·5 μ, for instance) will be kept in suspension indefinitely by the Brownian movements, so long as the particles remain finely divided. If, however, two or more particles agglomerate or coalesce, the force of gravity may cause the particles to settle to the bottom of the containing vessel. L. H. W.

610. *A Simple and Exact Derivation of the Maxwell Velocity-distribution Law.* **R. v. Mises.** (Phys. Zeits. 19. pp. 81–86, March 1, 1918.)—For the hypothesis that every possible velocity distribution in a gas the so-called Maxwell distribution may hold, namely, $m_i = Ae^{-h^2(v_i - c)^2}$, [where A, h, c, are constants, and m_i is the number of molecules with velocity v_i], a proof is given which is neither simple nor free from objections, being based on the Stirling formula which itself depends on the properties of the Euler Γ-function. Hence it is obscure to what degree of approximation the hypothesis is valid for a large number of molecules. In the present paper a quite elementary proof is given which is free from the objections involved in the earlier method. In Section 1 the problem is stated and discussed. In Section 2 the proof as based on Stirling's formula is examined, while supplementary hypotheses are introduced in Section 3. In Section 4 the proof of the main proposition is established. Section 5 contains numerical examples with tables of results. H. H. Ho.

611. *Some Problems of Atomic Stability.* **J. W. Nicholson.** (Phys. Soc., Proc. 30. pp. 65–82 ; Disc., 82, Feb., 1918.)—The paper is mainly concerned with the possible existence and stability of atoms, and of molecules formed after the manner suggested by Stark, the link between the atoms in a molecule being provided by a stationary electron on the molecular axis. Atoms on the Rutherford model, though dynamically unstable, are stable for the simple vibrations ordinarily excited ; but it is shown that atoms with such a stationary electron have a much more limited degree of stability. Moreover, they cannot exist even in an undisturbed state unless they are endowed with a negative charge, for no steady motion is possible, and this conclusion

extends even to atoms regulated according to a dynamics such as that of Bohr. Stark's conclusions do not, therefore, survive a quantitative treatment, and molecules cannot be formed in the manner he supposes.

The paper also discusses the more symmetrical problem, in which there are two such stationary electrons in an undisturbed atom, and it is shown that systems with a transitory existence, which are known by their spectra to occur in a solar corona, are apparently unaccompanied by the still more transitory systems which would be formed by the attachment of an electron after the manner of Stark. This is a further argument against the possibility that two atoms in a molecule can be linked by a single electron, or by two electrons, which attract both atoms. AUTHOR.

612. *The Lithium Atom.* **A. Hartmann.** (Archives des Sciences, 44. pp. 463–464, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—Sommerfeld [Abs. 361 (1917)] has recently arrived at a spectral formula for lithium founded on an extension of Bohr's theory, and one of his assumptions is that the two inner electrons describe a circular orbit of small dimensions compared to those of the outer one. The author finds that this hypothesis cannot be reconciled quantitatively with observed results, and no better result is obtainable by assuming that the orbital plane of the outer electron differs from that of the two inner ones. A very complete agreement, however, results from the assumption that the orbits of the two inner electrons, as of the outer one, are ellipses, the calculation being made by considering the electricity distributed over each orbit with a density proportional everywhere to the orbital velocity, and these ellipses can be made to satisfy the assumed quanta conditions. The necessarily approximate calculation gives Ritz's formula for the variable term of the series, and the undetermined constant in it can be so chosen that the constant p of the principal series has the observed value $-0{\cdot}048$, while the constants of the first secondary series and of Bergamann's series are, within the limits of error of the calculation, in accordance with those obtained experimentally. G. W. DE T.

613. *Thickness and Structure of the Capillary Layer of a Liquid in Contact with its Saturated Vapour.* **G. Bakker.** (Ann. d. Physik, 54. 4. pp. 245–295, March 1, 1918.)—Referring to his numerous papers since 1893, and more particularly since 1899, and to the capillarity theory of Laplace and Gauss, the author points out that the capillary energy is not the potential energy of the molecular forces of attraction, as Gauss assumed, but free energy, a quantity of the same nature as the external work done in the expansion and vaporisation of a body. There must be repulsive forces (the author's thermal pressure) in addition to the forces of attraction. If v_1 and v_2 are the specific volumes of the liquid and vapour, and p_N the vapour pressure, the diminution of the free energy by vaporisation is given by $p_N(v_2 - v_1)$. Similarly, when the surface of the capillary layer is altered, and $\bar{p}_T$ marks the mean hydrostatic pressure in the direction parallel to the surface of a capillary layer of thickness ζ, the increase in the free energy of the surface by one unit (in which case ζ numerically represents the volume) is given by $-\bar{p}_T\zeta$. On the other hand, the free energy $-p_N\zeta$ is lost when the capillary layer is formed from the homogeneous phases (liquid and vapour) without change of volume. There is hence altogether an increase of $(p_N - \bar{p}_T)\zeta$ in the free energy, and if H designate the capillary energy (numerically equal to the surface tension) $H = (p_N - \bar{p}_T)\zeta$. The author's potential function of the attractive forces at distance r is $-fe^{-(r/\lambda)/r}$ (Neumann), where λ is a small

length indicating the range of attraction [see Abs. 2138, 2139 (1900)], and the formula for the thickness of the capillary layer is $\zeta = 12\lambda^2 a(\rho_1 - \rho_2)^2/5H$; as ζ is equal to 6λ or $6{\cdot}5\lambda$ (previous papers), $\zeta = \gamma H/a(\rho_1 - \rho_2)^2$, where γ lies between 15 and 17 ; a is the coefficient of Laplace, and ρ_1 and ρ_2 are the densities of the liquid and the vapour. Thermodynamically it further follows that $\sqrt[3]{N} = iMr_i/[M\varepsilon_s]$, where N is Avogadro's number, Mr_i the inner molecular heat of vaporisation, and $[M\varepsilon_s]$ the molecular capillary energy, ε_s representing the expression $(H - Td H/dt)$ of Gibbs. At low temperatures ρ_2 vanishes, and the numerator in the last formula for ζ becomes $a\rho_1^2$, which is the molecular pressure of the liquid, designated by K ; thus $\zeta = 16H/K$. This value is 8 times larger than that of van der Waals-Kelvin, and the resulting values of ζ, for ether $2{\cdot}3\ \mu\mu$, water $1{\cdot}2\ \mu\mu$, etc., are likewise correspondingly larger. But the thickness of the capillary layer is not a definite quantity like the wave-length of a particular colour, and a is a temperature function, differently expressed by different workers. In the subsequent deductions the author accepts the equation of state of K. Onnes by preference to that of van der Waals. The considerations are confirmed by the data of various observers concerning N, O, A, CO, CO_2, CS_2, ether, benzol, mercury, etc. In the case of these non-associated bodies i has, near the melting-point, a value of $0{\cdot}38$ or $0{\cdot}4$; for associated substances (water, alcohols, etc.) i is smaller, ranging (by extrapolation) for water from $0{\cdot}147$ at 0° to $0{\cdot}231$ at 140° abs. The further arguments are on the lines of those in Abs. 284 (1916). Details of the calculations are given for benzol, CO_2, ether. Making the calculations of the thickness of the capillary layer ζ or of the number of molecular layers in it for the range from the melting-point up to the critical temperature T_K, by several methods, the author finds that the number of layers is, near the melting-point of the order 3, but much larger in the immediate proximity of the critical temperature ; if $\delta = T/T_K$, then for $\delta = 0{\cdot}999$ the number of molecular layers may for CO_2 lie between 300 and 1800. Thermodynamically ζ is found generally to be of the order $1{\cdot}5\ \mu\mu$ for $\delta = 0{\cdot}9$, but near T_K the thickness is, for CO_2, of the order of half the wave-length of ultra-violet light when $\delta = 0{\cdot}999$. From the fact that the capillary layer contains, at low temperatures, in general only 2 or 3 layers of molecules (apart from the immediate neighbourhood of the critical temperature), it is further concluded that the sphere of action of the attractive forces cannot extend beyond the nearest molecules. The classical arguments of the capillary theory cannot maintain their original significance, therefore, since they presume a sphere of action comprising many molecules. H. B.

614. *Theory of Brownian Movement.* **P. Ehrenfest.** (K. Akad. Amsterdam, Proc. 20. 5. pp. 680–683, 1918.)—Discusses an apparent paradox in the theory of the Brownian movement. Suppose a small sphere to be suspended in a fluid and that its Brownian movement is observed when it has a rather great velocity. May we expect the surrounding fluid to move with the sphere ? J. D. van der Waals, Jr., and Miss A. Snethlage [Abs. 985 (1916)] have recently shown how the answer to this question is connected with Einstein's theory of the Brownian movement. They also showed that the statistical theory of the molecular movement demands that such a common motion does not exist. This theory implies that for a given place and velocity of the suspended sphere and for a given configuration of the surrounding particles of the fluid, equal and opposite velocities of these particles are always equally probable. This result is somewhat paradoxical, but the treatment here given shows the paradox to be only apparent. Hence there is no

objection against Einstein's assumption that a suspended sphere during its Brownian movement imparts its motion to the surrounding fluid in the same way as in the case of a systematic motion under the influence of a constant force. A. W.

615. *Molecular Frequency and Molecular Number.* II. *Frequency of the Longer Residual Rays.* **H. S. Allen.** (Phil. Mag. 35. pp. 404–409, May, 1918.) [For Part I. see Abs. 458 (1918).]—A method of studying the frequency of vibration of the atoms in compounds is afforded by the "residual rays" obtained by repeated reflections from the surfaces of solids, and studied by Rubens and his collaborators. It may be assumed that the frequency of such infra-red radiation corresponds with the frequency of vibration of an electrically charged ion, and, in certain cases at least, it is to be expected that the ion in question may be identified with one of the atoms contained in the compound. The author has shown [Abs. 226 (1918)] that the characteristic frequency, ν, of the atom of a solid element is connected with the atomic number N by the relation $N\nu = n\nu_A$ or $N\nu = (n + \frac{1}{2})\nu_A$, where n is an integer, and ν_A a constant frequency having a value not far from 21×10^{12} sec.$^{-1}$. Seeing that the forces which control the vibrations of the atoms in solids are the same whether it be a question of the specific heat of the solid or the reflection of radiation, it might be anticipated that the same relation would hold in connection with the residual rays. The author has shown [Abs. 458 (1918)] that the molecular frequency is connected with the "molecular number" by a relation of the same form as that already quoted for the atomic frequency and the atomic number. The collective results suggest that the internal frequency may conform to the same relation. Experimental results are examined for a number of compounds, and it is found that there is a strong presumption in favour of the establishment of the relation suggested. The cases examined are: NaCl, KCl, KBr, KI, AgCl, $PbCl_2$, HgCl, AgBr, $CaCO_3$, NH_4Cl, NH_4Br, TlCl, TlBr, TlI. Using known values of the wave-lengths of residual rays for these substances the values of "n" in the above equation are shown, without exception, to be integral numbers.

The results of this and preceding papers support the following conclusions:—(1) The forces binding the atoms in the molecule are similar in character to those which bind the molecules of the solid—that is, the forces of chemical affinity are of the same nature as the forces of molecular cohesion. (2) There must be something of a discrete character in the nature of these forces, in order to account for the occurrence of integral values of "n." The simplest hypothesis is to assume that the forces arise from the presence of valency electrons. As it is probable that these forces act only in definite directions, it is a plausible suggestion that the linkages between the atoms are constituted by Faraday tubes of force, which would then be regarded as physical entities. The fundamental frequencies, ν and ν_A, would depend on the properties of the unit tube of force. Such a standpoint is interesting in view of Nicholson's work on Spectral Series [Abs. 1246 (1914)], and that of J. J. Thomson on "The Forces between Atoms and Chemical Affinity" [Abs. 1910 (1914)]—in which chemical valency is discussed with the same aspect. A. B. W.

616. *A Simple Deduction of the Generalised Lagrange Equations for Non-holonomous Coordinates.* **C. Schaefer.** (Phys. Zeits. 19. pp. 129–134, April 1, 1918.)—In Section 1 of this paper the general characteristics of coordinates are discussed. By the term "real coordinates" of a mechanical

system is understood the existence of a number of magnitudes which are sufficient to define at any instant the state of the system. Designating these by q_k $(k = 1, 2, \ldots n)$, where n represents the degrees of freedom of the system, then the differential with respect to time represents the velocity q_k, and a virtual change in a coordinate is given as usual by δq_k. Linear differential expressions between δq_k and certain functions can then be made which are integrable or not as the case may be. In the former the magnitudes are true coordinates; in the latter the inexact differentials are termed those of non-holonomous or quasi-coordinates. The present author now points out that the physicist has hitherto ignored the fact that for non-holonomous coordinates the Lagrange equations of the second degree are invalid in Dynamics. He now presents a case of fundamental importance in which the difference between the two kinds of coordinates is of outstanding significance, namely, in the derivation from the Lagrange equations of Euler's equations for rigid bodies fixed at one point. From this example the author states his conviction of the necessity of discussing the whole question in any introduction to Mechanics. In Section 2 of the paper the above example is worked out in detail. In Section 3, Kirchhoff's solution starting from the Hamiltonian Principle is examined. In Section 4 the case of a spinning-top is considered. H. H. Ho.

617. *Singularities in the Solution of the Problem of n-Bodies.* I. **E. Freundlich.** (Preuss. Akad. Wiss. Berlin, Ber. 8. pp. 168–188, 1918.)—The introduction to the paper contains a brief reference to previous work on the subject. Section I examines Painlevé's two hypotheses. Section II contains another proof of Painlevé's second hypothesis for any given value of n. Section III deals with the orbits of the bodies after direct impact. Section IV treats the general case of the impact of all the n-masses. The following stability theorem has been deduced: The simultaneous impact of all the n mass points of a system which conform to the Newtonian theory of gravitation, can only occur when at the outset all the n mass points are arranged in a central figure and move in straight lines towards the centre of gravity. H. H. Ho.

618. *Surface Tension and Angle of Contact of Mercury.* **R. Fürth.** (Akad. Wiss. Wien, Ber. 126. 3. pp. 329–345, 1917.)—Describes two new methods of investigating the surface tension and angle of contact with glass of mercury. In one method a convex lens is fixed at the bottom of a glass vessel and mercury is poured in until the lens is covered. The mercury is then allowed to escape slowly through a very small opening in the bottom of the containing vessel until the thin layer of mercury over the centre of the lens breaks and leaves a circular portion of the lens surface uncovered. If more mercury is run out the radius of this circular opening grows larger. If δ is the vertical distance between the surface of the mercury and the top of the lens, r_0 the smallest radius of the opening, r_1 the radius at the circle of contact of the mercury and lens, H the depth of the circle of contact below the surface of the mercury, and ρ the radius of curvature of the lens face, then the surface tension and the angle of contact can be calculated from measurements of these quantities for various diameters of the opening, which necessarily involves variations in the other quantities concerned. The other method is similar in principle, the lens in this case being secured to the bottom of a wide tube, which is movable by means of a micrometer screw in a vertical direction. The lens can thus be lowered gradually to the plane bottom of a

glass vessel containing mercury, and measurements made on the circular cavity between the lens and the plane bottom of the vessel when the two are nearly in contact. The two methods give concordant results, the value found for the surface tension being 440–445 dynes/cm. and for the angle of contact 128°–129° at 18° C. The experiments also permit of an estimation of a lower limit for the cohesion pressure in a layer of mercury. The value found is 150 gm./cm.^{2}. The methods are applicable to any solid-fluid combinations where the liquid does not wet the surface of the solid. A. W.

619. *West Indian Hurricanes as Observed in Jamaica.* **M. Hall.** (Monthly Weather Rev. 45. pp. 578–588, Dec., 1917.)—This account of West Indian hurricanes is put together to enable local observers to predict the movement of these disturbances and to supplement the warnings received by telegraph from the Weather Bureau at Washington. Some of the more important results have previously been published, but all are here collected in a form convenient for reference. The paper includes the following : (1) A diagram showing the mean paths of hurricanes grouped in northern, intermediate, and southern tracks for each of the hurricane months, Aug., Sept., and Oct. (2) The relation between fall of barometric pressure below normal and distance from the centre. The fall becomes more rapid as the centre approaches. (3) The incurvature of the wind from the isobars on different sides and at different distances from the centre. The incurvature becomes smaller as the centre approaches. (4) The relation between the velocity of the wind and the fall of pressure. A typical feature of these hurricanes is the calm, or relatively calm, area in the centre. In the region immediately outside this calm area the wind velocity is found to agree closely with the cyclostrophic component of the gradient wind, that is, the pressure gradient accounts for the centrifugal acceleration and the term due to the earth's rotation is relatively unimportant.

It is found, as might be expected, that the upper currents, as revealed by cloud motion, show a more intimate connection with the direction of the radius vector from the centre of the hurricane than the surface winds. The cirrus blows almost directly away from the centre on all sides. In undisturbed conditions over the West Indies the Trade Winds extend up to a height of 4 or 5 miles while the cirro-form clouds above may move from any direction, but from the west as a general average. Using the laws which have been set out in the earlier part of the paper for the air motion the tracks of air masses are calculated as in Shaw and Lempfert's " Life History of Surface Air Currents," and it is found that hurricanes are not of the closed system or vortex type, but are constantly fed with fresh air drawn in on the right front and in this way are similar to the depressions of our own latitudes. [See Abs. 8 (1918).] J. S. Dr.

620. *Diurnal Variation of Wind with Height.* **L. Dunoyer.** (Comptes Rendus, 166. pp. 45–48, Jan. 7, 1918.)—It was shown in a recent paper [Abs. 234 (1918)] that in general the velocity of the wind at moderate heights (200 to 1000 m.) is greater than at lower levels during the night. In the present paper it is pointed out that the statement applies to easterly and westerly winds almost exclusively. An explanation is put forward, based upon the diurnal temperature wave and the corresponding diurnal pressure wave induced thereby. This pressure wave would be shown as a region of relatively high pressure on the side of the earth remote from the sun and relatively low pressure on the side facing the sun ; with comparatively steep pressure gradients in the two transition longitudes where dawn and twilight

are respectively found. The effect of this distribution would be to produce an increase of easterly wind component in the evening and of westerly component in the morning. This is found to agree with observation. In a later paper (*ibid.* pp. 293–295, Feb. 18, 1918) the author puts forward certain consequences of the theory which are to some extent borne out by observation. **C. E. Brazier.** (*ibid.* pp. 176–177, Jan. 28, 1918.)—Brazier shows that the actual diurnal variation of pressure in Paris is altogether inadequate to account for the diurnal variation of wind velocity as measured at the summit of the Eiffel Tower, in the manner suggested by Dunoyer. He says that the Espy-Köppen theory is similarly untenable, and refers to a theory of his own, an outline of which has been prepared but not published. R. C.

621. *Diurnal Variation of Wind with Height.* **Reboul.** (Comptes Rendus, 166. pp. 295–297, Feb. 18, 1918.)—Observations show that, in the free air from 200 m. to 1000 m., in the middle of the day, there is in general a decrease in wind velocity and a counter-clockwise rotation of its direction. At the beginning or at the end of the night there is, on the contrary, an increase of velocity and a clockwise rotation of direction. R. C.

622. *Temperature Correlations in the United States.* **T. A. Blair.** (Monthly Weather Rev. 45. pp. 444–450, Sept., 1917.)—Correlation coefficients were worked out between mean temperatures for Jan. at stations in Southern California, and at a number of other stations distributed over the United States, and the results were plotted on a map against the position of the second station in each case. Isocorrelational lines are then drawn from + 0·9 in California through 0·8, 0·7, etc. to 0·0, which runs roughly north and south through the middle of the States, proceeding through — 0·1, — 0·2, etc. to — 0·7, which forms a small closed oval to the north-east of the Gulf of Mexico. This shows that there is a well-marked temperature "see-saw" in Jan. between California and Florida. Similar relationships exist in other months, but not to such a marked degree. R. C.

623. *The Turning of Winds with Altitude.* **W. R. Gregg.** (Monthly Weather Rev. 46. pp. 20–22, Jan., 1918.)—From a discussion of the higher kite and balloon ascents at Mount Weather, Va., eight rules have been formulated for change of wind with height under different pressure conditions. The following are examples. (1) With a distant "low" approaching from the south-west surface winds are easterly and shallow, and above them is a layer about 1 km. in depth in which there is little or no wind; above this layer south-westerly winds prevail. (2) As a "low" passes north of the station surface winds are successively south-east, south and south-west, and the turning of wind with altitude is clockwise, the upper winds nearly always being south-west to west. It was found that at 4 km. above sea-level the wind had a component from the west in 96 % of the cases recorded, and at this level winds with a north component were nearly twice as frequent as winds with a south component. J. S. Dr.

624. *On Severe Winters.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 52. pp. 738–759, 1917.)—A "character-number" to express the degree of severity of any winter is obtained in the following way: The mean temperature in degrees Centigrade for each day of the months Nov., Dec., and Jan. is taken; of these the negative values are selected and added together; the result, viz. the sum of the negative daily means, is the

character-number. Of the last 150 winters in Berlin, 24 are classified as "very severe." The most severe was the winter of 1829/30, and that of 1788/9 was almost as severe. The winter of 1916/7 comes out only as a moderately severe one. Since the middle of the 19th century the number of very severe winters has been much reduced; in the period 1788 to 1845 that number was great, namely 17. A very severe Berlin winter is associated with the presence of a prolonged snow-covering, and a westerly position of the continental high-pressure system. R. C.

625. *Solar Halo of February* 4, 1918. **J. P. Henderson** and **A. F. Hunter.** (Roy. Astron. Soc. Canada, J. 12. pp. 153–156, April, 1918.)—There have been records of mock suns being visible before the sun has risen above the horizon. A. F. Hunter (paper 2) observed a case of this kind before sunrise on Feb. 4, 1918, at Barrie, Ont., but keeping the phenomenon under observation the correct explanation became evident. It appeared that these were not true mock suns but parts of the primary halo a little above the horizon, the part on the horizon being cut off by a slight bank of haze. The true mock suns rose later. It is probable that previous observations of this kind can be explained in the same way. In paper (1) J. P. Henderson describes halo phenomena seen on the same day at Toronto. J. S. Di.

626. *Solar Coronæ: Five Years Recent Observations.* **J. Maurer.** (Archives des Sciences, 44. pp. 349–350, Nov., 1917. Monthly Weather Rev. 45. p. 577, Dec., 1917. Paper read before the Swiss Soc. of Geophysics, etc., Zurich, Sept., 1917.)—Examination of the sky shows that the sun is often surrounded by a large white luminous circle the diam. and intensity of which are subject to great variations. Observations commenced in 1912 showed at first two distinct minima in the diam. annually, the first in April–May and the second in Aug.–Sept. More recently it has appeared that this feature is not invariable; in 1916 the course was quite different. In April of that year the diam. reached nearly 100° and towards the end of August nearly 140°. The luminous circle presents very remarkable phases at epochs of great solar activity. When its diam. is 70–80° it is surrounded by a broad border distinctly coloured, of a tint between red and yellow-brown. It appears probable that the circle is associated with the emission of particles from the sun which are caught in the upper layers of the earth's atmosphere. Further observations are desirable. J. S. Di.

627. *Mechanical Evaluation of Seismograms.* **W. Schmidt.** (Akad. Wiss. Wien, Ber. 126. 2. pp. 113–123, 1917.)—Describes, with diagrams, a pendulum arrangement which it is proposed to make, whose period of oscillation, damping, etc., can be made the same as for a given seismograph pendulum. A heavy disc with attached weights (5 to 20 kg.) is suspended by two or three wires from a bearing provided with a pointer. This pointer is caused to follow a seismogram driven by clockwork, and a second arm attached to the disc may then be used for evaluating the forces brought into play during the time the seismogram was being obtained. The damping of the disc is electromagnetic and so can be varied at will, and by varying the distance of the attached weights from the centre of the disc the moment of inertia of the system, and consequently its period of vibration, may be altered so that the system will correspond to the seismograph in question. A. W.

628. *On Ground-water Movements according to Isothermal Curve Systems.* **P. Forchheimer.** (Akad. Wiss. Wien, Ber. 126. 4. pp. 409–440, 1917.)—

This paper dealing with subterranean water movements is entirely mathematical. The various problems are considered under 13 sections, namely: (1) At a point series of borings; (2) At fissure series; (3) At a transverse wall half the depth of the impermeable layer; (4) At a transverse wall reaching to any given depth; (5) The case of lateral stream flow; (6) Parallel fissures; (7) At the roof where the subterranean stream is lowest; (8) At a transverse wall with rounded base; (9) At catch corners; (10) Substances of irregular permeability; (11) Symmetrical surfaces; (12) Dense river-beds; (13) Water emergence. H. H. Ho.

629. *Earthquake Frequency.* **R. D. Oldham.** (Nature, 101. p. 159, April 25, 1918. Abstract of paper read before the Geolog. Soc., Feb., 1918. Phil. Mag. 35. pp. 504–507, June, 1918.)—The paper is a study of the gravitational effect of the sun as shown by the 20-year record of Italian earthquakes. The diurnal distribution brings out the following points:—(1) The summer range of stress is greater by day than night, but the winter range has the opposite variation. That this range is seasonal is confirmed by the divergence being greatest at the height of each season. (2) There is a diminution of downward pressure during the six hours preceding, and an increase during the six hours following the sun's transits. There is also a close relation between the frequency of shocks and the variation of vertical stress, though none with the horizontal or total stress. The greatest number of shocks is at the period when there is the greatest increase of downward pressure, and the frequency diminishes with the rate of increase. These results provide a means of estimating the rate of growth of strain producing earthquakes, and hence of the time required to prepare for an earthquake. W. A. R.

630. *Locating Submarine Faults.* **O. Klotz.** (Roy. Astron. Soc. Canada, J. 12. pp. 57–60, Feb., 1918.)—Examination of seismograph traces with well-marked time scales show that it is possible to locate the corresponding epicentres with sufficient accuracy to indicate the probable line of faulting producing the disturbance. An example is given in the case of the universally recorded earthquake of 1915 May 1. While one adopted epicentre gave a position off Onekotan Island, that from the seismogram from Perth gave a position off Urup Island, indicating a fault line 500 km. long, running in a NE.–SW. direction along the well-known Kurile deep. Greater openness of the time scales is required for finding whether the breakdown is simultaneous or progressive. C. P. B.

631. *Photography of Solar Spectrum from* λ6800 *to* λ9600. **W. F. Meggers.** (Astrophys. J. 47. pp. 1–6, Jan., 1918.)—By means of plates stained with dicyanin, photographs of the solar spectrum extending to λ9600 have been obtained with a 5-in. plane grating and camera of 18 ft. focal length at the Johns Hopkins University during April and May 1917. Reproductions of the photographs are given, and from comparisons with laboratory spectra of 40 chemical elements some 400 lines have been identified with lines of 18 known elements, leaving about 1600 lines still unidentified. C. P. B.

632. *Absorption and Radiation of the Solar Atmosphere.* **S. Hirayama.** (Math. Phys. Soc. Tōkyō, Proc. 9. pp. 236–240, Feb., 1918.)—Computations of the transmission and radiation of the solar atmosphere by Schuster's method, using the recent measurements at the Smithsonian Astrophysical Observatory, are compared with the results given by Biscoe from the same material but neglecting the effect of radiation of the solar atmosphere [Abs. 757 (1916)]. The tables of residuals indicate that the observations are better represented

than in Biscoe's table. The coefficient of transmission increases gradually with the wave-length. The radiation due to the solar atmosphere is also tabulated; it is about one-third of the whole radiation for short wave-lengths and approaches to one-half as the wave-length increases. Assuming the effective temperature of the sun to be 6000° abs., the temperature of the photosphere is calculated to be about 7040° abs., and that of the absorbing layer about 5210° abs. [See Abs. 1606 (1913).] C. P. B.

633. *Internal Temperatures of the Sun.* **A. Véronnet.** (Comptes Rendus, 166. pp. 109–111, Jan. 21, 1918.)—An investigation is made of the law of densities operating on a gaseous mass of similar nature and at the temperature of the sun, 6000°. The variation found would be about 22 deg. per km., indicating that at a certain depth a pressure of 11,000 atmos. and a max. temperature of 60,000° would combine to confer on any gaseous masses the potentiality of explosive expansion which when released might produce the surface phenomena with which we are familiar. C. P. B.

634. *Contraction of a Gaseous Mass.* **A. Véronnet.** (Comptes Rendus, 166. pp. 286–289, Feb. 18, 1918.)—Calculations are made of the conditions induced by the contraction of a gaseous mass, with special application to the case of the evolution of the sun. [See preceding Abs.] C. P. B.

635. *Diffraction from a Circular Source.* **M. Hamy.** (Comptes Rendus, 166. pp. 240–245, Feb. 11, 1918.)—Application is made to the case of the sun of the investigation of the luminous intensity given in the image of a circular source by a telescope whose lens is diaphragmed by a straight slit. The problem is of interest in connection with the determination of the sun's diameter, where the best possible definition of the limb is required. A suggestion is made regarding the site suitable for making such observations. A region comprising a plateau of some 3000 m. altitude, covered with snow, would probably offer good conditions for steadiness of image. [See Abs. 518 (1918).] C. P. B.

636. *Perihelion Progress of Mercury.* **O. Lodge.** (Nature, 101. pp. 44–45, March 21, 1918.)—It is suggested that the perturbation of the perihelion of Mercury may be produced by the sweeping up of solar matter, such as yields the zodiacal light, as the planet moves in its orbit. **H. Jeffreys.** (Nature, 101. p. 103, April 11, 1918.)—Jeffreys points out that the action of a resisting medium would not necessarily produce any effect on the mean distance of a planet, as suggested by Lodge. Moreover, the density needed to produce such an effect is calculated to be far greater than is likely to be present in whatever material produces the zodiacal light. The abnormality with reference to Mercury is not the only unexplained perturbation, as there is an advance of the node of Venus of the same order of magnitude. **H. Jeffreys.** (Nature, 101. p. 145, April 25, 1918.)—Further notes are given in relation to Lodge's resistance suggestion, stating that although the absolute resistance would be expected to be greater at perihelion than at aphelion, on account of the different density at these points, this difference would contain the eccentricity as a factor, and the rate of decrease of eccentricity and the motion of perihelion would be of same order. Reference is also made to the conclusion of G. W. Walker [Phil. Mag. 35. p. 327, 1918], that one effect of the difference between longitudinal and transverse electromagnetic masses would be a change in the plane of a planet's orbit. C. P. B.

637. *Physical Observations of Venus in* 1917. **R. Innes.** (Union Observat. S. Africa, Circ. 41. pp. 342–343, Jan. 4, 1918.)—Observations were commenced

on 1917 Nov. 15, with the object of finding the exact date of dichotomy. The conclusion is that this occurred on 1917 Nov. 23, whereas the predicted time from the Nautical Almanac was 1917 Nov. 29·9. The three observers all noted that the edge of the planet was very bright, and that a darkish line runs along the terminator. C. P. B.

638. *Lunar Crater Eimmart.* **Maggini.** (L'Astronomie, March, 1918. Nature, 101. p. 153, April 25, 1918. Abstract.)—This interesting crater, about 40 km. in diam., is situated on the north-western edge of the Mare Crisium, and has been specially studied in view of the apparent changes recorded by W. H. Pickering. Certain portions were of exceptional brightness in Sept. 1915 and Oct. 1916, and it is suggested that they may originate in the craterlet on the western rampart, which is surrounded by a white deposit. C. P. B.

639. *Libration of the Trojan Planets.* **W. M. Smart.** (Roy. Astron. Soc., Mem. 62. Part 3. pp. 79–112, 1918.)—The theory of "Lagrange's Three Particles" became of practical interest in 1906 when the small minor planet Achilles was discovered with mean motion and heliocentric distance almost identical with those of Jupiter, and whose position was roughly the vertex of an equilateral triangle with Sun-Jupiter as base. Three other bodies were later found roughly fulfilling the same conditions. The theory of their motion is worked out on the basis of Jacobi's Canonic Equations as modified by Delaunay, with an approximation to the 6th order of small quantities, for the principal librational terms due to the long-period terms. In a subsequent paper it is hoped to give the results due to the secondary long-period terms. C. P. B.

640. *Observations of Cepheid Variable S.U. Cassiopeiæ.* **W. S. Adams** and **H. Shapley.** (Mt. Wilson Solar Observat. Contrib. No. 145. Astrophys. J. 47. pp. 46–50, Jan., 1918.)—Spectrograms of the star obtained at Mt. Wilson are discussed in relation to the spectroscopic parallax, variation of velocity and changes in spectral type. There seems to be evidence that the period is not constant, but provisionally it is taken as 1·9495 days. The elements of the velocity curve are typical of Cepheid variables that have small ranges of velocity and nearly similar velocity curves. A diagram is given showing the variation of spectral type in relation to the variation of light. The spectroscopic parallax agrees well with the determination of $+0{\cdot}010''$ by van Maanen, if the visual magnitude is taken as 6·23, as given in the Preliminary General Catalogue. C. P. B.

641. *Changes in Spectrum of Wolf-Rayet Star γ Argus.* **C. D. Perrine.** (Astrophys. J. 47. pp. 52–54, Jan., 1918.)—Observations of the spectra of bright-line hydrogen stars, Wolf-Rayet stars, and the brighter stars of classes B and A have recently been commenced at the National Observatory at Cordoba. In the course of these evidence was found that changes occurred in the spectrum of γ Argus. The spectra were photographed with a 5-in. objective prism attached to the astrographic equatorial, giving a dispersion of 35 A. per mm. at H_γ. During an interval of three months there has been a well-defined change in the structure of H_β, and a less marked change near λ4500. Comparisons with the old spectra taken at Harvard and with Campbell's results appear to confirm the change. There is also a broad, faint brightening near the positions of the principal nebular lines. C. P. B.

642. *Photo-visual Magnitudes of Stars in Pleiades.* [**Miss**] **H. McW. Parsons.** (Astrophys. J. 47. pp. 38–46, Jan., 1918.)—Measurements were

made with a Hartmann microphotometer on 20 plates of the Pleiades region obtained with either the Zeiss doublet camera or the 24-in. reflector. The table of results shows that the colour-index increases with the fainter stars.
C. P. B.

643. *Stars in Pleiades not belonging to the Physical System.* **J. A. Parkhurst.** (Astrophys. J. 47. pp. 51–52, Jan., 1918.)—Attention has been called by Miss Parsons to Trümpler's list of twelve stars projected on the Pleiades group, but having proper motions so different from the rest as to suggest detachment from the system [see preceding Abs.]. The data from both papers are here collected, and from the discussion it is concluded: (1) that down to 8·7 magnitude all stars having colour-indices as large as 0·30 are shown by their large relative proper motion (compared with Alcyne) to belong outside the system; (2) that all stars, with few exceptions, having large relative proper motions have also large colour-indices, and are therefore in a different stage of evolution from the members of the system. These facts thus tend to prove the homogeneity of the physical system of the Pleiades. C. P. B.

644. *Light-curves of Short-period Variables.* **T. E. R. Phillips.** (Roy. Astron. Soc., M.N. 78. pp. 185–187, Jan., 1918.)—Plummer and Martin having recently shown that the light-curves of eight short-period variables exhibit similar characteristics to those of stars in the second of the two groups in which Phillips divided the long-period variables, Phillips now extends the comparison by analysing the light-curves of the 18 short-period variables in Pickering's Class IV. The resulting tables show that the short-period variables are also divided into two groups, although the evidence for one of them is at present not strong. There is thus a marked tendency of variable stars of all known periods (including the sun) to exhibit light-curves conforming to one or other of two types with distinct characteristics. As bearing on Shapley's theory of pulsations in a single star, it would be of interest if systematic search could be made for variations of radial velocity of some of the long-period variables synchronising with the light changes. C. P. B.

645. *Photographic Magnitudes with Vatican Astrographic Equatorial.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 78. pp. 180–183, Jan., 1918.)—An analysis of the Vatican photographic magnitudes is made to determine the corrections depending on distances from the plate centre, showing that zones of defective focus occur which affect the magnitudes of the constituent stars.
C. P. B.

646. *Solar Motion and Stream Motion from Stars of Late Spectral Types.* **G. Strömberg.** (Mt. Wilson Solar Observat. Contrib. No. 144. Astrophys. J. 47. pp. 7–37, Jan., 1918. Nat. Acad. Sci., Proc. 4. pp. 36–41, Feb., 1918.)—In a previous paper Adams and Strömberg showed that the intrinsically faint stars have a higher velocity than those that are intrinsically brighter [Abs. 1106 (1917)]. The subject has been continued by studying the solar motion and stream motion as functions of absolute magnitude, based on stars of the spectral types F, G, K, and M. For stars of types F, G, and K there seems to be a steady increase of average radial velocity with decreasing brightness, and for all three types a break in the linear relationship corresponding to the division into giants and dwarfs. The intrinsically bright stars have a higher galactic condensation than the fainter stars. The K-term of galactic concentration appears to be positive for the brighter stars

and negative for the fainter stars. No decided relationship could be found between the constants of the solar motions and absolute brightness. C. P. B.

647. *Suspected Nova in Spiral Nebula N.G.C.* 2841. **F. G. Pease.** (Astron. Soc. of the Pacific, Publ. No. 171. pp. 4–5, Oct., 1917.)—A photograph taken at the 25-ft. focus of the 60-in. reflector with an exposure of 2 hours on 1912 Feb. 19, shows a relatively bright nebulous star in the spiral nebula N.G.C. 2841, which does not appear on earlier and later plates made at the Lick Observatory. [Abs. 1351 (1917).] C. P. B.

648. *Novæ in Spiral Nebulæ.* **G. W. Ritchey.** (Astron. Soc. of the Pacific, Publ. No. 171. pp. 2–4, Oct., 1917.) –Comparisons of photographs of the spiral nebula H. IV. 76 Cephei (N.G.C. 6946) show that on the plate of 1917 July 19 a small star of 14·6 magnitude was present in the southern branch of the inner and brighter parts of the spiral, which was absent on previous plates taken in 1916, 1915, 1912, and 1910. No opportunity occurred of obtaining a spectrogram of the star until Aug. 16, when a good record was made with 6 hours' exposure at the 25-ft. focus of the 60-in. reflector, using a slitless spectrograph of very low dispersion. The continuous spectrum on this plate is strong and crossed by what appears to be a series of bright bands. This discovery led to examination of all the available negatives of spiral nebulæ made with the 60-in. reflector since 1908, from which search several other objects were found to exhibit variations indicating their being either novæ or variables. C. P. B.

649. *Magnitudes of Novæ in Spiral Nebulæ.* **H. Shapley.** (Astron. Soc. of the Pacific, Publ. No. 171. pp. 5–8, Oct., 1917.)—Since Ritchey's discovery of the nova in N.G.C. 6946 the number of temporary stars known to have occurred in nebulæ has increased so rapidly that an opportunity is afforded of making preliminary use of relative magnitudes in estimating the order of the distances of spiral systems. The galactic latitudes of the objects noted are so decidedly different from those of the usual new stars, which are generally in or near the galaxy itself, that they may be considered as connected with the spirals. The magnitudes of the galactic novæ have varied from -5 to $+10$, with an average of 5·5, at maximum, while that of eleven temporary stars in spirals is $+14$. If the two classes of objects are regarded as of similar *absolute* brightness, this would mean the larger spiral nebulæ are at least 50 times more distant than the galactic novæ. Various problems depending on these views are discussed. C. P. B.

650. *Dimensions of a Globular Cluster.* **H. Shapley.** (Astron. Soc. of Pacific, Publ. No. 172. pp. 1–4, Dec., 1917.)—As an example of the attempt to determine the dimensions of globular clusters, M 3 (N.G.C. 5272) is chosen as being one of the brightest northern globular clusters. It is very rich in cluster-type variables, about 150 having hitherto been recognized. These are very similar in length of period (about 13 hours) as well as in range of variation and in the form of light-curve. The parallax corresponds to about three thousand million (3×10^9) times the distance of the sun from the earth. To illustrate the enormous dimensions of the system, a photograph taken by Ritchey with the 60-in. reflector is shown with a rectangular *reseau*, one square of which represents 5×10^6 times the distance of earth to sun. The most distant variable star of the system from the centre is 14×10^6 astronomical units (earth to sun). It is estimated that light takes 470 years to cross the diameter of the cluster. C. P. B.

651. *Globular Clusters and Structure of Galactic System.* **H. Shapley.** (Astron. Soc. of Pacific, Publ. No. 173. pp. 1–13, Feb., 1918.)—The methods of determining distances of globular clusters are summarised, mainly depending on the computed relation of absolute magnitude to the observed period of the Cepheid and other variables which have been investigated. Distribution diagrams of the known globular clusters show clearly that the galactic plane is their fundamental and symmetrical plane, with a conspicuous region of avoidance extending about 2000 parsecs north and south of the galactic equator. The general discussion leads to the conclusion that the globular clusters outline the extent and arrangement of the total galactic organisation, so that all known sidereal objects must be considered as parts of a single whole. It also appears unlikely that the spiral nebulæ can be considered separate galaxies of stars. The sun is very excentrically situated in the general system, being some 20 parsecs north of the plane and about 100 parsecs from the centre of a very open local aggregation. This local group is about half way from the centre to the edge of the galaxy. C. P. B.

652. *Bright Variable Star in N.G.C.* 6779 (*Messier* 56). **H[elen] Davis.** (Astron. Soc. of the Pacific, Publ. No. 171. p. 2, Oct., 1917.)—From an examination of plates taken by Shapley and Pease, a variable star that is apparently of the Cepheid type has been found in the globular cluster N.G.C. 6779. Referred to the polar standards, the observed range of photographic magnitude is from 14·43 to 15·20; the photovisual magnitude near maximum is 13·3, giving a colour index of + 1·1. No other variable is known in the system. C. P. B.

653. *Faint Nova in Andromeda Nebula.* **H. Shapley.** (Astron. Soc. of the Pacific, Publ. No. 171. p. 5, Oct., 1917.)—Two photographs made with the 60-in reflector on 1917 Sept. 11 show a new star of magnitude 17·5 at a distance of 10′ from the centre of the nebula. The object is invisible on a photograph taken by Pease on 1917 Aug. 21, and no trace appears on any of the plates of longer exposure listed by Ritchey in a preceding Note [Abs. 648 (1918)]. A further special plate taken by Ritchey on 1917 Sept. 17 shows the star to have decreased about half a magnitude in six days. C. P. B.

654. *Photographic Determinations of Stellar Parallax.* **A. C. D. Crommelin.** (Yerkes Observat. Publ. 4. Part 1. Nature, 101. p. 88, April 4, 1918. Abstract.)—The parallax work at Yerkes Observatory was begun in 1903 by Schlesinger, and continued by Slocum, Mitchell, Lee, Joy, and van Biesbroeck. Results of 85 determinations are detailed, with summaries of earlier results on 46 stars. Most of the parallax stars are bright, but nearly one-third are faint stars with large proper motions. Six of the 85 parallaxes are between 0·1″ and 0·2″, three above 0·2″, and 76 less than 0·1″. Probable errors are all of the order of 0·01″. Two precautions were observed in the work: (*a*) all plates were taken at small hour-angles, so as to minimise the effect of unequal atmospheric dispersion, and the reduction of the magnitude of the parallax star to equality with the comparison star, mainly by rotating a sector screen in front of the brighter image; also (*b*) Kapteyn's plan of interposing an out-of-focus negative of the same region was adopted, so that the blurred star discs present a series of graduated screens whose intensity depends on the magnitude of the individual stars. An appendix to the volume gives a detailed description of the Gaertner measuring machine. C. P. B.

655. *Are the Spiral Nebulæ External Galaxies?* **A. C. D. Crommelin.** (Scientia, May, 1917. Roy. Astron. Soc Canada, J. 12. pp. 33–46, Feb., 1918.) From the first division of the nebulæ by Herschel into the two classes of gaseous and stellar it has been a debated question whether these objects were members of our system or were independent galaxies far removed. Modern investigations of proper motion and radial velocity indicate that our sun lies excentrically in a great system of stars, the shape of the system being lenticular ; it is supposed to extend to a distance of one or two thousand light-years on either side in the flattened portions, while in the direction of the galaxy it extends three or four times as far. Photography has greatly increased our knowledge of nebula structure, and it is now known that the spiral structure is the normal configuration of the white nebulæ. When examined statistically, the evidence appears to indicate that Wolf-Rayet stars, diffused gaseous nebulæ, loose star clusters and novæ in general belong to our own star system, and the same probably applies to most of the globular clusters. Considerable evidence on this question may ultimately be derived from a study of the regions where absorbing matter appears to be present. In the case of the spiral nebulæ, the case is quite different. A study of their distribution shows that there is a rich region near the north galactic pole, and one of less marked richness near the south galactic pole, and discussion of various views regarding this fact leads to the conclusion that the spirals are external objects with respect to our galactic system. An important feature of the spectra of the spirals is the indication that they have enormous speeds of translation and rotation—the former reaching in some cases to 1100 km./sec., and the rotation up to 300 km./sec. at 2′ from the centre. It was also found by Pease that in N.G.C. 4594 the rotation speed appeared to vary proportionately to the distance from the centre. If the spirals are accepted as extra-galactic, then they must be of dimensions quite comparable to those of our galaxy. It is probable that they are at an earlier stage of their career, and that most of their components are in the Wolf-Rayet or other early stages of evolution, while much of their matter is still scattered or diffused in clouds, which reflect some of the starlight. C. P. B.

656. *Compressibility of Dwarf Stars and Planets.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 78. pp. 183–184, Jan., 1918.)—An analysis is made concerning the degree to which the incompressibility of the substance of a star or planet affects the possible vibrations of the body. C. P. B.

657. *Magnitudes of Cape Photographic Durchmusterung.* **J. Halm.** (Roy. Astron. Soc., M.N. 78. pp. 199–211, Jan., 1918.)—Investigation of the magnitudes of the Cape Photographic Catalogue shows that the scale of the Cape system is in satisfactory agreement with that of the Mount Wilson system for both high and low galactic latitudes. The only serious discrepancy is shown by the low latitude group of zone —45°, and this is ascribed to the action of a cosmical cause which makes the stars in that region appear photographically brighter. C. P. B.

658. *Relation between Star-counts and Apparent Magnitudes.* **J. Halm.** (Roy. Astron. Soc., M.N. 78. pp. 212–230, Jan., 1918.)—An investigation is given of the mathematical theory of the statistical relations of star-counts and apparent magnitudes, with somewhat more general views of the physical assumptions which may be tested later by observation. C. P. B.

659. *Spectrum and Radial Velocity of Spiral Nebula N.G.C.* 1068. **V. M. Slipher.** (Lowell Observat. Bull. No. 80. Nature, 101. p. 114, April 11, 1918.

Abstract.)—Photographs taken at the Lowell Observatory with a two-prism spectrograph and an exposure of 35 hours, show that the bright hydrogen lines extend farther into the faint parts of the nebula than do the two green nebular lines, and that both bright and dark lines are strongly inclined, indicating a velocity of rotation of about 300 km./sec. at 1′ from the nucleus. The radial velocity is 1120 km./sec. recession. C. P. H.

660. *Light-curve of Variable W Virginis.* **C. A. Chant.** (Roy. Astron. Soc. Canada, J. 12. pp. 47–56, Feb., 1918.)—Discovered by Schönfeld in 1866, the subsequent observations by the discoverer indicated a period of 17·27? days, with an interval of 8·1 days from maximum to the preceding minimum, and the light-curve accepted shows a single broad maximum. Later Schmidt, in 1872, found similarities to the variation of the η-Aquilæ type, with a secondary minimum. Schönfeld made further observations and still concluded that the existence of a double maximum was improbable, and his final value for the period was 17·27231 days. Later observations with somewhat differing results are then discussed, and finally an investigation of 498 photographs taken by the Harvard College Observatory during the period 1894 April 24 to 1916 Feb. 3, gives a mean light-curve of the δ-Cephei type, period 17·2711 days. This shows that the true time of maximum is approximately 2·05 days earlier than that given by the Chandler formula, and that the rise from minimum to maximum requires about 6·37 days, nearly the usual third of the period. The descent to minimum is so protracted that it almost forms a secondary maximum, as in the case of S Sagittæ. The neighbouring variable V Virginis, 29′ South following, was also shown in the plates. C. P. B.

661. *Auroral Observations in the Antarctic.* **D. Mawson.** (Roy. Soc. of S. Australia, Trans. 40. pp. 151–212, 1916. Nature, 101. pp. 114–115, April 11, 1918. Review.)—The Note is a review by C. Chree of a paper prepared in 1911 by Mawson, dealing with the auroral observations at Cape Royds, Antarctic. In general the curtain is regarded as the fundamental form, streamers, when present, representing the visible parts of an invisible curtain. The discussion of the observations is illustrated by two figures showing (*a*) the diurnal variation in the frequency, (*b*) the relative frequency with which aurora was observed in the different geographical directions. Only the observations of June, July, and Aug., 1908, were employed, and the station being at lat. 77° 32′ S, the sun was continuously below the horizon and the disturbing effects of daylight or twilight at a minimum. Whereas observers in the northern hemisphere have usually found the max. frequency before midnight, at Cape Royds this occurred about 3.0 a.m., and was also found by L. C. Bernacchi during the first Scotch Antarctic Expedition, 1902–4. With regard to geographical direction, the most marked feature was the small activity on the west. Mawson inclines to the view that this may be due to the open sea on the east, while land areas prevailed on the east, but Chree points out that it may only mean that Cape Royds lies within the zone of max. auroral frequency. The daily observations give the impression of the aurora being at no great height, and as this is different from the result found by Störmer for northern auroræ the subject should be further investigated. Numerous instances are recorded of the auroral curtains being directed towards the sun, and several cases where a disturbance of the shape appeared to be caused by Mt. Erebus. Further observations obtained during 1912–13 are thought to be more comprehensive. C. P. B.

LIGHT.

662. *New Stellar Photometer.* **M. Maggini.** (Comptes Rendus, 166. pp. 284–286, Feb. 18, 1918.)—Light from an artificial source is reflected from a small silvered portion of a glass plate inserted at 45° in the path of the rays from an object-glass to the eyepiece. The focus is adjusted so as to give an out-of-focus image, in the centre of which will be seen the illuminated silver disc. Adjustments are then made so that the artificial light is just invisible on the starlight. Difficulties owing to differences of colour of starlight and artificial comparison are remedied by interposing coloured screens. C. P. B.

663. *Reflection of Surfaces with Negative Curvature.* **P. Selényi.** (Phys. Zeits. 19. pp. 105–109, March 15, 1918.)—Describes in detail the image formation in the case of mirrors similar to a serviette ring smaller in diameter at the middle, a section of the ring by a plane passing through the axis consisting of segments of two circles whose centres lie outside the ring. The surface considered is, in fact, generated by the revolution of a segment of a circle about a line in its plane lying altogether outside the circle and parallel to the tangent at the middle point of the segment. A. W.

664. *Scattering of Light.* **Rayleigh.** (Phil. Mag. 35. pp. 373–381, May, 1918.)—A mathematical treatment of the scattering of light by a cloud of similar small particles of any shape and oriented at random. Expressions are derived for the ratio of intensities of the two polarised components in the light scattered at right angles, (i) for particles symmetrical about an axis and (ii) for particles of any shape whatever. A. W.

665. *Behaviour of Scattering Media in fully diffused Light.* **H. J. Channon, F. F. Renwick,** and **B. V. Storr.** (Roy. Soc., Proc. 94. pp. 222–237, March 1, 1918.)—The first portion of the paper is mathematical, the authors deducing from first principles equations for the "transmittance" of media, *i.e.* the ratio of the light issuing from, to that impinging on a sheet; the inverse of this quantity is described as "obstructance." The formulæ derived are shown to be in general agreement with Schuster's solution for the emergent radiation through a given thickness of a self-radiant foggy atmosphere. Experiments have shown that for plates of opal glass and other granular media the relative obstructance D is related to the thickness t as follows: $D = at^b$, where a and b are constant for the medium and the conditions of measurement. No physical explanation of this rule is apparent. It has therefore been examined with great care, and has been confirmed for piles of specimens of similar thickness subject to the elimination of surface reflection by the use of thin films of cedar-wood oil. J. S. D.

666. *Visibility of Radiation in the Blue End of the Visible Spectrum.* **L. W. Hartman.** (Astrophys. J. 47. pp. 83–95, March, 1918.)—With the aid of a suitable blue-glass screen used in connection with the direct-comparison method of determining the visibility of radiation in the blue end of the spectrum, measurements have been made by twenty different observers, and values of visibility between the limits 410 $\mu\mu$ and 500 $\mu\mu$ were obtained. Corrections were made for slit-widths, for scattered light, and for the absorption of the optical system of the apparatus. Inasmuch as a very bright source of light was employed, and a bright but small retinal image, and since consistent results with no apparent shift of the visibility curves were obtained

with different widths of the collimator slit and with different brightnesses of the comparison source, it is believed that any error due to the Purkinje effect was eliminated. Using the values of visibility of radiation obtained by this method for the interval of wave-lengths given above, and for the temperature interval 1781° to 2475° K., the effective wave-length for two thicknesses of blue-glass filter was found to be 466·8 $\mu\mu$. The experimentally determined value of the effective wave-length was 467 $\mu\mu$. [See Abs. 164 (1915) and 155 (1918).] A. W.

667. *Brightness Sensibility of the Retina.* **J. Blanchard.** (Eastman Kodak Co.'s Research Lab., Comm. No. 45. Phys. Rev. 11. pp. 81–99, Feb., 1918.)—In studying threshold, contrast, and glare sensibility the author employs adaptations of methods used by Nutting and others. The apparatus consists of a white board with a small central aperture containing a piece of opal glass illuminated by transmitted light. The brightness of the glass could be adjusted by interposing between it and the source a wedge of absorbing gelatine. Threshold sensibility is plotted for different colours, the curve for white light with logarithmic coordinates being practically a straight line. Experiments covered a range from 10^{-6} to 10^{4} millilamberts. Similar data are presented for contrast sensibility illustrating Fechner's fraction. In regard to glare, curves illustrate the course of dark adaptation with white light, and with different colours. Here again the relation between the log. of the least brightness that appears approximately glaring and the log. of field brightness is found to be linear. Reference is made to the variability of the pupil aperture, the diameter of which, with a field brightness varying from zero to 2000 millilamberts, altered from 2 to 7·4 mm. The flux density on the retina is also calculated, being $7{\cdot}0 \times 10^{-12}$ for a field brightness of 0·00001 millilambert and $1{\cdot}1 \times 10^{-4}$ for 2000 millilamberts. J. S. D.

668. *Visibility of Radiation.* **P. Reeves.** (Eastman Kodak Co.'s Research Lab., Comm. No. 55. Phil. Mag. 35. pp. 174–181, Feb., 1918. Am. Illum. Eng. Soc., Trans. 13. pp. 101–108; Disc., 108–109, Feb., 1918.)—Visibility curves throughout the spectrum have been obtained, among others, by Nutting and Ives [Abs. 1026 (1916), 49 (1918)]. The author has also investigated the curves obtained by different subjects with a special form of apparatus, a modification of Nutting's colorimeter, which he describes. He assembles on one diagram Nutting's curve derived from 21 subjects, Ives's curve (18 subjects), the curve (13 subjects), and a curve calculated from Nutting's formula, $V = V_m R^a e^{a(1-R)}$, where $R = \lambda_{max.}/\lambda$ and $a = 181$. The above formula well represents visibility values between 0·48 μ and 0·67 μ, and the four curves agree closely. The max. visibility occurs at 0·553 μ, in agreement with Ives's curve, as compared with 0·555 μ for Nutting's curve. J. S. D.

669. *Resolution of Mixed Colours by Differential Visual Diffusivity.* **H. E. Ives.** (Phil. Mag. 35. pp. 413–421, May, 1918.)—The author has previously described experiments on visual diffusivity, *i.e.* the lagging of different colours relative to each other, these phenomena being applied to explain the action of the flicker photometer [Abs. 623 and 928 (1917)]. In these experiments inconclusive results were obtained with some mixed colours such as purple. The author now repeats the experiments by arranging four red, purple, and blue to form successive portions of a line of light on a disc. On rotation the mixed colour is resolved by lateral displacement of its component images. Thus the purple becomes two overlapping red and blue

images. Similarly mixed yellow can be resolved into red and green, but this is not the case with a pure monochromatic yellow. This result appears to have an important physiological bearing and the author considers it in the light of various theories of colour vision. In particular the different behaviour of pure yellow and its subjectively equivalent mixed yellow is difficult to reconcile with the three-colour theory. J. S. D.

670. *Radiation Efficiencies of Light Sources.* **F. Conrad.** (Ann. d. Physik, 54. 5. pp. 357–400, March 11, 1918.)—Describes the filter employed in conjunction with a thermopile to give the latter the same sensitivity curve as that of the normal eye. By means of this filter the light efficiencies of various sources are compared. The result obtained experimentally in the case of a black body at 1395° K. agrees with that obtained by calculation (0·0044 %). The efficiencies found for other sources of various kinds are shown in the following table :—

Source.	Photometric Efficiency (Watts per m.h.c. (Hefner)).	Light Efficiency (Per cent.).
Carbon filament	27·07	0·049
	4·12	0·33
	2·27	0·61
Tungsten filament	1·96	0·85
	0·81	2·1
Nernst lamp	4·01	0·32
	1·88	0·80
Mercury arc	1·78	2·0
	0·28	6·5
Arc lamp	—	(9)

J. W. T. W.

671. *Approximate Methods in obtaining Constructional Data for Telescope Objectives.* **T. Smith.** (Phys. Soc., Proc. 30. pp. 119–126 ; Disc., 126, Feb., 1918.)—The paper discusses the reason why satisfactory telescope objectives are obtained by neglecting thicknesses and solving for freedom from first-order aberrations. It is shown that the introduction of thicknesses into such an objective without any alteration in the curvatures of the surfaces yields a lens corrected for aberration for a zone which is a constant fraction of the full aperture obtainable. For objectives of the usual type this zone is very approximately the one that would be selected for correction to obtain the most favourable balance between first- and second-order aberrations. It follows that objectives calculated from first-order formulæ in which thicknesses are neglected do not require trigonometrical verification or correction unless the conditions are very abnormal. AUTHOR.

672. *Primary Monochromatic Aberrations of a Centred Optical System.* **S. D. Chalmers.** (Phys. Soc., Proc. 30. pp. 100–117 ; Disc., 117–118, Feb., 1918.)—The paper describes approximate methods of treatment of the first-order aberrations of a centred optical system. Two methods are used, one primarily suited to the case where the separation of the surface is small, and the other more suited for use where the separations vitally affect the design.

The aberrational defects are expressed as lateral aberrations—*i.e.* as defects measured in the focal plane of the system. The procedure adopted is to express the aberrational defect of a single surface in terms of the constants of the surface, and the perpendicular distance of the ray considered from the centre of curvature of the surface. The value of this perpendicular can be expressed in terms of the coordinates of the ray in any chosen medium, and thus the aberration due to each surface can be expressed in terms of the coordinates of the chosen ray, in such a way that the aberrations of the individual surfaces can be summed. AUTHOR.

673. *On Methods for detecting small Optical Retardations, and on the Theory of Foucault's Test.* **Rayleigh.** (Phil. Mag. 33. pp. 161–173, Feb., 1917.)

674. *Two Cases of Congenital Night-blindness.* **W. de W. Abney.** (Roy. Soc., Proc. 94. pp. 59–64, Dec. 1, 1917.)

675. *Constant-deviation Prisms.* **H. S. Uhler.** (Astrophys. J. 47. pp. 65–82, March, 1918.)—The important properties possessed by so-called quadrilateral prisms giving a deviation of 90° are here generalised for any feasible constant deviation δ. The most fundamental single fact brought out by this part of the analysis is that, at effective minimum deviation, the deviation (δ) is always equal to the interior angle (ω) between the incidence and emergence faces of the prism, The position of the axis of rotation, given by Forsythe [Abs. 940 (1917)] for $\omega = 90°$ is shown to hold for any triangular prism producing a constant deviation δ, and it is also shown that the axis of rotation, which must be perpendicular to the plane containing the optic axes of the collimator and telescope, must lie in the plane which bisects the angle between these axes. A formula is derived connecting the angle of incidence with the ratio in which the point of incidence of the axial ray divides the incidence face. As corollaries of this equation, criteria are given for determining whether the extreme rays of a beam will or will not strike the incidence face of the prism. A. W.

676. *Structure of the Bismuth Line* λ4722. **L. Aronberg.** (Astrophys. J. 47. pp. 102–103, March, 1918.)—The results of Luneland and of Wali-Mohammad [Abs. 1252 (1914)] as to the position of the satellites of the Bi line λ4722, differ greatly from those of v. Baeyer, v. Baeyer and Gehrcke, and Takamine. In the first two investigations an echelon grating was used while in the three latter the method of crossed spectra was employed. In the present investigation the line was examined in the sixth order of a Michelson 10-in. plane grating in a Littrow mounting of 30 ft. focus. As source of light an oxy-kathode arc was employed, in form slightly modified from that used by Wali-Mohammad [Abs. 1252 (1914)]. The results obtained show that the measurements of Luneland and Wali-Mohammad are incorrect as to the actual positions of the satellites. In order to find the exact wave-length of the lines a trace of Zn was mixed with the Bi, so that the Zn line λ4722·164, which is very sharp and single, was photographed with the Bi line. With equal quantities of the Zn and Bi the Zn line came out self-reversed and good measurements could be obtained. The values obtained for the wave-lengths of the various components in international units, starting with the strongest one, are: 4722·379, 4722·435, 4722·481, 4722·619, 4722·663, and 4722·697. A. W.

677. *Arc Spectrum of Europium and of a New Element between Europium and Samarium.* **J. M. Eder.** (Akad. Wiss. Wien, Ber. 126. 4. pp. 473–531,

1917.)—Continuing his systematic investigation of the spectra of the rare earths [Abs. 949 (1917)], the author has now completed measurements of the wave-lengths of the lines in the arc spectrum of europium. A table is given of the wave-lengths and intensities of about 1200 lines from λ7370 to λ2373. Investigation showed no indication of europium being anything but a simple element, but in dealing with a europium fraction containing samarium, a number of unknown lines were discovered which seem to belong to a hitherto unknown substance lying between europium and samarium and to which the name euro-samarium has been given. A europium preparation which was free from samarium did not give the new lines, nor were they obtained with Auer v. Welsbach's purified samarium. The new spectrum was not found by Rütten in a samarium preparation free from europium, prepared by Drossbach, nor in Demarçay's samarium investigated by Exner and Haschek. The lines, over 200 in number, extend from λ6300 to φ3260, and most of them are of low intensity. It is possible that they may belong to one or more of the known elements of the group of rare earths whose spectrum has not been sufficiently investigated, but the evidence so far tends to the conclusion that they belong to a new substance. A. W.

678. *Spectrum of the Isotopes of Lead.* **L. Aronberg.** (Astrophys. J. 47. pp. 96–101, March, 1918.)—Describes an examination of the spectrum of ordinary lead and of lead of radio-active origin. The latter was obtained from Australian carnotite. In order to obtain a very bright source, and at the same time to have the spectral lines very sharp and narrow, a slightly modified form of the oxy-kathode arc *in vacuo*, employed by Wali-Mohammad, was used. A comparison spectrum of the two kinds of lead taken on a quartz spectrograph showed at first a change of intensity in the lines λ2833 and λ2823, but this was found to be due to a difference of pressure in the two vacuum arc lamps. With the pressure the same in the two lamps, no change either in intensity or in the number of lines could be detected. With a Michelson 10-in. plane grating in a Littrow mounting of 50 ft. focus the only line that could be photographed in the higher orders within reasonable exposure times was the line λ4058, the strongest line in the lead spectrum. In order to detect any small changes in wave-length the two arc lamps were connected in parallel to the mercury pump and exposures were taken at the same time to avoid any mechanical shifts. The voltage and current of the two arcs were maintained the same throughout, except when the voltage in one lamp was purposely made 3 or 4 volts below the other. Measurements on 16 plates showed that the radio-lead gives a line, slightly longer wave-length than ordinary lead. The average difference for the λ4058 line was 0·0044 Å.U. With the radio-lead replaced by ordinary lead no difference could be observed in the wave-length, but with radio-lead in one lamp the difference always appeared. Assuming the ordinary lead to have an atomic weight of 207 and the radio-lead 206, the nuclear charge being the same, calculation from Bohr's theory shows that λ4058 of the radio-lead should be increased by 0·00005 Å.U., which agrees in sign but not in magnitude with the observed value. The fact that there was an actual shift of the line in the ordinary lead and not a mere broadening of the line would suggest the conclusion that ordinary lead is not a mixture of thorium and radium lead, but is a pure isotope by itself. [Abs. 558 (1915).] A. W.

679. *Spectrum of Boron.* **A. de Gramont.** (Comptes Rendus, 166. pp. 477–480, March 25, 1918.)—Using an oxy-acetylene flame and various boron compounds rough measurements were made of the position of the

numerous bands exhibited. The following are the wave-lengths obtained : λλ4920, 4709, 4530, 4340, 4190, and 4020. These numbers can only be regarded as approximate owing to the diffuse character of the bands. As regards the ultimate lines of boron the following results were obtained, using boric acid with a given weight of sodium carbonate : λ3451·20 was obtained with boron in the proportion of $1 : 10^4$. The doublet lines λ2497·82 and λ2496·87 were obtained with boron in the proportions $1 : 10^5$ and $5 : 10^5$ respectively. In the case of a certain steel containing 0·67 % of boron the line λ3451·20 is given much stronger than the iron lines and is very easily recognisable. With the condensed spark the doublet is very easily seen owing to the reduction of intensity of the iron lines by the inductance in the circuit. The same method has revealed the presence of boron in certain minerals in which it had not previously been detected. A. W.

680. *Spectrum of Lightning.* **J. B. Cannon.** (Roy. Astron. Soc. Canada, J. 12. pp. 95–97, March, 1918.)—Tables of wave-lengths obtained from measurements of two photographs of the spectrum of lightning, are given with comparison values from Slipher's spectrum. The results confirm the close agreement with many of the lines of the air spectrum given by Neovius.
C. P. B.

681. *Crystal Structure of the Alums and the Rôle of the Water of Crystallisation.* **L. Vegard** and **H. Schjelderup.** (Ann. d. Physik, 54. 2. pp. 146–164, Feb. 15, 1918.)—The structure of 4 alums has been determined by Bragg's α-ray reflection method. The alums studied are : ammonium alum $NH_4Al(SO_4)_2 . 12H_2O$, potassium alum $KAl(SO_4)_2 . 12H_2O$, iron-ammonium alum $NH_4Fe(SO_4)_2 . 12H_2O$, and chrome alum $KCr(SO_4)_2 . 12H_2O$. Using the Rh line as monochromatic X-radiation, a table is given of reflection angles and relative intensities of the X-ray beams. From these values models are constructed showing the complete structure of the crystals indicating the position of the H_2O molecular groups. In all cases the structure is very complex. A. B. W.

682. *Absorption of the Radiation emitted by a Palladium Antikathode in Rhodium, Palladium, and Silver.* **E. A. Owen.** (Roy. Soc., Proc. 94. pp. 339–352, May 1, 1918.)—A preliminary account is given of some experiments carried out with the rays from an ordinary X-ray bulb. A spectrum of the rays from a Pd antikathode is obtained over a limited range of wave-lengths by reflection in the (111) face of a carborundum crystal. The spectrum shows that the bulb emits a continuous band of wave-lengths upon which are superposed the characteristic rays of the metal of the antikathode, and, under the conditions of working in this particular case, the relative intensities of the different wave-lengths in the spectrum remain approximately constant.

There is a minimum of intensity in the spectrum corresponding to the wave-length $0·493 \times 10^{-8}$ cm. On the assumption that the minimum is due to the selective absorption of this wave-length in the crystal, the value $0·493 \times 10^{-8}$ cm. is assigned to the β-line of the J-series of silicon. From the experimental results of Barkla and White [Abs. 166 (1918)] on the J-series of the elements Al, C, and O, the approximate values deduced for the β-line of the J-series of oxygen and carbon are $0·519 \times 10^{-8}$ cm. and $0·559 \times 10^{-8}$ cm. respectively.

Assuming Bragg's mean value of the α-line of palladium to be $0·586 \times 10^{-8}$ cm. the following values are obtained for the wave-lengths

of the β- and γ-lines : $\beta = 0{\cdot}520 \times 10^{-8}$, $\gamma = 0{\cdot}509 \times 10^{-8}$ cm. The absorption coefficients of the rays from the bulb have been measured in rhodium, palladium, and silver. The results show that the connection between wave-length and absorption coefficient is expressed by the relation $\tau/\rho = K\lambda^3$, where $\tau\rho$ is the fluorescent coefficient and K is a constant for a given substance over a range of wave-lengths between the absorption bands of that substance.

The critical wave-length necessary to excite the characteristic rays of a substance, lies in the neighbourhood of the β-ray of that substance. The α-ray is not excited until the β-ray is excited.

It is pointed out that the purity of the characteristic lines emitted by a bulb and isolated by reflection at a crystal face will depend to a certain extent upon the working of the bulb. A. B. W.

RADIO-ACTIVITY.

683. *Distribution of Radio-active Gases in the Open Air.* **V. F. Hess** and **W. Schmidt.** (Phys. Zeits. 19. pp. 109–114, March 15, 1918.)—A theoretical treatment based on the laws of diffusion. Formulæ are obtained for the distribution of the various radio-active gases (radium, thorium, and actinium emanations) in the atmosphere with respect to distance from the surface of the earth. The calculated values agree satisfactorily with observation. Laws are also deduced relative to the supply of radio-active substances to the atmosphere from the surface layers of the earth, and good agreement is again obtained with experimental results. Thorium and actinium emanations can only be detected in the lowest layers of the atmosphere to any appreciable extent. The conclusions with regard to the distribution of the emanations will also apply to the solid decay products. If the height at which the air content of a certain radio-active substance is reduced to half that at the surface of the earth, be denoted by h, then the following table shows the value of h for different substances :—

Substance.	h.
RaEm and its decay products of short life...	About 1200 m.
RaD and succeeding members of series	Practically uniform to 10 km.
ThEm and ThA	2–3 m.
ThB and succeeding members of series	100–150 m.
AcEm and AcA.....	0·5–1 m.
AcB and succeeding members of series	10–20 m.

A. W.

684. *Theory of Kaufmann and Bucherer's Investigations on β-Rays.* **R. Malmström.** (Phys. Zeits. 19. pp. 43–47, Feb. 1, 1918.)—Mathematical. A. B. W.

685. *Radio-activity of Lake Rockanje.* [Miss] **H. J. Folmer** and **A. H. Blaauw.** (K. Akad. Amsterdam, Proc. 20. 5. pp. 714–735, 1918.)—A determination of the radio-active contents of numerous samples of mud taken from Lake Rockanje (in the Isle of Voorne, near the Hook of Holland). The final conclusions reached by the authors are summed up in the statement "that the Lake of Rockanje possesses no radio-activity of any importance." Any radio-active matter detected in the mud must be ascribed to the alluvial deposits from rivers. All the samples examined (about 60 in number) have an activity such as has generally been found in soils of the kind. A. B. W.

HEAT.

686. *Further Notes on a High-temperature Thermostat.* **J. L. Haughton** and **D. Hanson.** (Inst. of Metals, J. 18. pp. 173–184, 1917. Engineering, 104. pp. 412–414, Oct. 19, 1917. Abstracts in Engineer, 124. pp. 322–323, Oct. 12, 1917. Electrician, 80. pp. 89–90, Oct. 19, 1917.)—Describes the alterations made to an apparatus previously described that make it suitable for temperatures much higher than 500° C.—the limit in the former apparatus [Inst. of Metals, J. 14. p. 145, 1915]. L. H. W.

687. *Experimental Researches on the Thermal Conductivity of Gases.* I and II. **S. Weber.** (Ann. d. Physik, 54. 5. pp. 325–356, March 11, and 54. 6. pp. 437–462, March 21, 1918.)—The relationship between the thermal conductivity of gases and the internal friction, and the variation of both these magnitudes with temperature has been, since the establishment of the kinetic theory of gases, the object of a large number of theoretical and experimental investigations to which reference is made. Chapman's work [Abs. 636 (1912), 794 (1916)], which dealt only with monatomic gases, and from which the conclusion was drawn that their atoms were symmetrical, is first discussed. Schleiermacher's method is examined at great length and the sources of error such as radiation, electrode loss, thickness of glass walls, temperature, convection currents, etc., are investigated. The author shows that it is possible by a rational construction of apparatus, which he describes in detail, together with the introduction of suitable corrections to arrive at an accurate method. The principal feature of Part I is the investigation of convection effects and their elimination. Results for dry air free from CO_2 were given. In Part II data are given for certain pure gases, using the apparatus described in Part I. The gases were: hydrogen [see Abs. 1245 (1913)], helium, argon, nitrogen, oxygen, methane, carbon dioxide, nitrous dioxide. In each case the methods of preparing the pure gas are given, with tables of results for the thermal conductivity. The dependence of the latter on temperature is dealt with at some length. The results obtained show a special behaviour of hydrogen; at higher temperatures this gas is diatomic, but at temperatures in the neighbourhood of liquid air it gives the monatomic curve, which at the lowest point lies almost on the argon curve. The course of the curve is in consonance with the hydrogen molecule losing its internal energy at lower temperature. In the group of diatomic substances, oxygen, nitrogen, and carbon monoxide behave similarly, the curves being parallel to the argon and helium curves. At lower temperatures the curves for oxygen and nitrogen appear to approach the argon curve. H. H. Ho.

688. *Theoretical and Experimental Researches on the Thermal Conductivity of Gas Mixtures.* III. **S. Weber.** (Ann. d. Physik, 54. 7. pp. 481–502, April 9, 1918.)—On account of the great importance of the half-watt lamp in lighting technology, the thermal conductivities of gas mixtures have acquired enhanced interest. In order to be in a position to investigate the conditions and relationships at higher temperatures, it is of importance to have those at lower temperatures for the kinetic thermal conductivity of the mixture. Knudsen's method [see Abs. 899 (1911)] is employed for deriving a formula which shall represent the thermal conductivity of a gas mixture. This formula is then discussed in its application to common gas mixtures, *e.g.* nitrogen and oxygen, oxygen and hydrogen, argon and helium, hydrogen and

carbon dioxide. It is found that none of these usual gas mixtures give a maximum or minimum value for the thermal conductivity when the theoretical values of the constants are used in the formula. The author next examines more rigidly the behaviour of air and of oxygen-hydrogen, after which he considers the interesting mixture of light hydrogen molecules with heavy carbon dioxide. Tables of results and curves are given. The discussion of some measurements of the thermal conductivity at 0° C. of mixtures of nitrogen and argon concludes the paper. These latter mixtures are of technical importance because of their use in the half-watt lamp. H. H. Ho.

689. *Specific Heats of Lead-Antimony Alloys.* **R. Durrer.** (Phys. Zeits. 19. pp. 86–88, March 1, 1918.)—If both components of a binary system in a definite concentration zone possess complete non-miscibility in the solid state, then according to Tammann the specific heat of the alloys at constant temperature within this zone should be a linear function of the concentration. Experiments have been made previously on the systems Bi-Sn, Fe-Fe_3C, Bi-Cd. In the case of bismuth-tin alloys the curve of the specific heats exhibits concavity according to O. Richter. Larger deviations from the straight line were found for bismuth-lead alloys. The specific heats of both systems were determined between 0° and 100° C. A. Meuthen has found that the specific heats of alloys of iron-carbon, which he examined between 650 and 0° C., lie on 2 straight lines which intersect at a concentration of 0·95 %. In contrast to these deviations from the linear path, the researches of Levin and Schottky for the specific heats between 17° and 100° C. for Bi-Cd and Fe-C alloys have afforded data which agree, within experimental error, with the above rule. The same holds good for the experiments described in this paper for the specific heats of Pb-Sb alloys within the temperature range of 20° to 100° C. The method of Levin-Schottky was employed. Control experiments are described in detail. Tables of results accompanied by curves are given.
H. H. Ho.

690. *The Combustion of an Explosive Gas Mixture within a Closed Vessel.* **L. Flamm** and **H. Mache.** (Akad. Wiss. Wien, Ber. 126. 1. pp. 9–44, 1917.)—The calculations put forward in the paper relate to the theoretically simplest, and, in consequence, the most frequently investigated case of a spherical-shaped bomb containing a combustible gas mixture which is ignited exactly in the centre. Nägel's work is first referred to. The most important data for the problems investigated are the rise of pressure in the bomb during the progress of the combustion, and the temperature and specific volumes of the combustion products. A formula is obtained which, in the author's opinion, will afford a better interpretation of the experimental results than those hitherto in use, owing to the smaller number of assumptions made. The question is also investigated as to how far the important explosion method of Mallard and le Chatelier for the estimation of the specific heats of gases at high temperatures needs correction on account of the temperature variations which arise after the combustion commences. The relationship is also examined between the change of the combustion velocity of a gas mixture and its initial temperature and pressure, whereby an insight is afforded into the mechanism within an explosion-motor. Section 1 deals with the mechanism of the combustion procedure inside an explosion bomb. In Section 2 the combustion itself is mathematically investigated. The differential equation for an explosion is evolved in Section 3, and its integration discussed in Section 4. In Section 5, the formula expressing the final result is evolved. Section 6 is occupied with a discussion of Hopkinson and Pier's

experiments and results. Finally Section 7 is devoted to the evaluation of the velocity of combustion. H. H. Ho.

691. *Some Problems of Evaporation.* **H. Jeffreys.** (Phil. Mag. 35. pp. 270–280, March, 1918.)—This is a mathematical treatment of the problem of evaporation, from which it is shown that when evaporation takes place in still air, the rate of evaporation is proportional to the first power of the linear dimensions of the evaporating surface, but that when a steady current is passing, the rate of evaporation is proportional to the $\frac{3}{2}$ power of the linear dimensions. These results have both been confirmed in practice previously by other workers. A discussion follows of the rate of evaporation from leaves. Evaporation from a single cylindrical stoma is first considered, and it is shown that in many actual cases the total evaporation from a wet leaf would not be as much as that from the combined stomata in the leaf, supposing each stoma to evaporate according to the formula. This being absurd, it follows that evaporation from any stoma must be enormously restricted by the presence of other stomata in its immediate neighbourhood. R. C.

692. *Formula for the Tension of the Saturated Vapour of a Diatomic Liquid.* **E. Ariès.** (Comptes Rendus, 166. pp. 447–450, March 18, 1918.)—The formula for the tension of the saturated vapour of a monatomic body has been already determined [Abs. 545 (1918)]. The method there employed is now extended to the case of a diatomic substance, and first consists in the evaluation of the exponent n of τ in the equation of state by assuming as a first approximation that the co-volumes α and β are constant. The author finds that for diatomic bodies the single value for n is $\frac{3}{4}$, and that the co-volumes must be considered as functions of the temperature. Experimental data are given for chlorine and carbon dioxide. The formula, $T = 1 + [(1 - \tau)(0\,86 - \tau)]/(A\tau^3 + \beta)$, is found to give good agreement between the observed and calculated tensions for these gases. H. H. Ho.

693. *On the Anomalies presented by the Saturated Vapour Tensions of certain Diatomic Liquids.* **E. Ariès.** (Comptes Rendus, 166. pp. 553–556, April 8, 1918.)—In a previous communication [see preceding Abs.] formulæ have been established which give the saturated vapour tensions of chlorine and of carbon monoxide. The data, however, are insufficient to permit of a decision as to whether these formulæ apply to all diatomic bodies. In the present paper the data for five more diatomic substances are examined, namely: oxygen, nitrogen, nitric acid, hydrochloric acid, and hydriodic acid. At elevated temperatures and up to the critical state the observed tensions of nitrogen vapour agree sufficiently well with the tensions calculated by means of the formulæ; but at lower temperatures and for oxygen throughout the whole range of the temperatures explored, the observed tensions, especially at the low temperatures, are notably superior to those calculated. Similar anomalies are pointed out in the cases of the other diatomic bodies considered. It is shown, however, that four diatomic bodies at least exist whose properties fit in with the law of corresponding states. H. H. Ho.

694. *On Wood's Criticism of Wien's Distribution Law.* **H. Jeffreys.** (Phil. Mag. 35. pp. 410–412, May, 1918.)—[See Abs. 386 (1918).]

695. *On the Nature of Heat, as directly deducible from the Postulate of Carnot.* **J. Larmor.** (Roy. Soc., Proc. 94. pp. 326–339, May 1, 1918.)

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

696. *The Lommel-Weber Ω Function and its Application to the Problem of Electric Waves on a Thin Anchor Ring.* **J. R. Airey.** (Roy. Soc., Proc. 94. pp. 307–314, May 1, 1918.)—For the mathematical treatment the original must be referred to. L. H. W.

697. *Electric Waves.* **W. S. Franklin** and **B. McNutt.** (West. Soc. Eng., J. 22. pp. 589–622, Nov., 1917.)—An illustrated discussion (almost wholly mechanical) of the simplest aspects of the dynamics of wave motion. The subject is dealt with under the following heads:—Equation of a travelling curve; Partial differential equation of travel; Principle of superposition (a property of linear differential equations); Undetermined constants in the solution of an ordinary differential equation; Differential equations of motion of a stretched string; Pure wave travelling to the right; Reflection and change of phase thereby; Examples of wave motion on a string; The Kelvin ladder; Differential equations of electrical wave motion on a transmission line; Effect of travelling distribution of current; Effects of travelling distribution of voltage; Mutually sustaining voltage and current distributions; Wave-form; Reflection from short-circuited end of line; Transmission line oscillations which follow the switching on of a generator; Transmission lines surges which are produced when a circuit-breaker opens. L. H. W.

698. *On the Problem of Three Electrified Spherical Conductors.* **A. Anderson.** (Phil. Mag. 35. pp. 388–396, May, 1918.)—By using the electrostatic theorem previously given [Abs. 399 (1918)] the author shows how the electrostatic coefficients of three electrified spherical conductors can be computed. Approximate formulæ are obtained for the case of three small equal conducting spheres whose centres are at the corners of an equilateral triangle. A. R.

699. *Electrostatics of a Conducting Sphere in a Spherical Cavity.* **A. Russell.** (Roy. Soc., Proc. 94. pp. 206–217, March 1, 1918.)—Formulæ suitable for computation are developed from which complete numerical evolutions are obtainable of three problems which are of practical importance to physicists and engineers: (1) The calculation of the capacity of a spherical condenser when the centre of the inner sphere does not coincide with that of the cavity — required for determination, by means of a spherical condenser, of the ratio of the electrostatic and magnetic units, and also for the construction of condensers of variable capacity. (2) The calculation of the electrostatic force acting upon the inner sphere — required for the design of an absolute electrometer in which one sphere is suspended within another. (3) The calculation of the max. value of the electric stress on the dielectric — required for determinations, by means of a spherical condenser, of the electric strengths of insulating materials. The determination of the electric strengths of dielectrics is a problem of great urgency just now, and the question of finding satisfactory methods for making such measurements is being dealt with by the Research Committee of the Institution of Electrical Engineers. G. W. de T.

700. *Electrification by Friction.* **J. A. McClelland** and **C. J. Power.** (Roy. Irish Acad., Proc. 34. Section A. pp. 40–50, April, 1918.)—This is an attempt to study this subject quantitatively. The pressures between the rubbing surfaces, their speed, their temperature, the hygrometric state of the air, and the surrounding gas pressures are all varied at will. A disc of wood is hollowed out on one face and across the hollow is stretched silk or linen. This is one of the rubbing surfaces. The other surface is a metal spherical cap attached to a lever so that the pressure of metal on the fabric can be varied at will. The metal is joined to one pair of quadrants of an electrometer; by this means the rate of charging of the metal is observed. Certain metals such as Ag, Pt, Fe, and Ni are negatively charged against silk, but copper becomes positive. On linen Fe is positive, but Ni and Pt are negative. It is important to note that the standard condition for the metal surface is one of polish. The same surface polished may be positive, unpolished negative. It is found that the negative charge on Ag, Pt, or Fe, rubbed with silk increases in proportion to the rate of revolution of the disc, whereas the positive charge on Cu rises to a constant maximum at all speeds of disc above 20 ft./sec. whatever the pressure between the surfaces. This difference in behaviour of the two classes of metal may be connected with the observed effect that increase in temperature tends to make the metal acquire a negative charge; for obviously, increased speed would be accompanied by rise in temperature of the rubbers.

The temperature of the hollow metal caps is changed by running through them water or steam. It is found that rise in temperature decreases the charge when this is positive but increases it when it is negative.

To observe the effect of hygrometric changes in the air, the apparatus is introduced into a box whose air is first dried and then moistened slowly by a stream of saturated air. The rubbing is carried on during the process, and it is found that if the metal is positively charged the charge rises to a sharp maximum, as dampness increases and then falls slowly for increased dampness. But if the metal is negatively charged the charge rises more slowly to a max. value which remains constant for any increase in dampness.

A further change in the form of the experiment consisted in introducing the apparatus into a vacuum vessel. At the lowest pressures, say 0·01 mm. of mercury, the rate of charge production is very small, but for a negatively charged metal this rises quickly to a sharp maximum at pressure about 0·1 mm. and then falls more slowly to the highest pressures used, say 0·8 mm. In the case of a positively-charged metal the rise is slower to the maximum which occurs at 0·8 mm. for Cu on linen, and 1·25 mm. for Fe on linen. The evidence is that the pressure at which maximum occurs is determined by the substance, whether fabric or metal, that is charged positively.

No theory of these results is given at present. P. E. S.

701. *Origin of Increase of Ionisation of the Atmosphere with Height.* **A. Gockel.** (Phys. Zeits. 19. pp. 114–115, March 15, 1918.)—Discusses the results obtained by Dember [Abs. 1075 (1912) and 189 (1918)] on the Peak of Teneriffe at a height of 3200 m. Various considerations lead to the conclusion that Dember's results were affected much more by increased wind strength than by radiation from the sun. It appears more probable that the source of the increase of ionisation with height is to be found in the rays of great penetrating power. The fact that with a sky free from cloud the air in the higher layers of the atmosphere is much poorer in condensation nuclei than in the lower layers, is also of considerable importance. A. W.

DISCHARGE AND OSCILLATIONS.

702. *The "Vosmaer Phenomenon."* **W. C. Moore.** (Am. Electrochem. Soc., Trans. 31. pp. 391–395; Disc., 395–396, 1917. Met. and Chem. Eng. 16. pp. 557–558, May 15, 1917.)—The light phenomenon occurring when two nickel electrodes are made the terminals of an induction coil was investigated as to the effects of using different electrodes, different pressures of air between the electrodes, and different gases between the electrodes. A theoretical explanation of the various effects is attempted. AUTHOR.

703. *Influence of a Series Spark on the Direct-current Corona.* **S. J. Crooker.** (Am. J. Sci. 45. pp. 281–300, April, 1918.)—Describes experiments carried out with the object of investigating further some results obtained by Farwell [Abs. 1166B (1914)] when a short spark was placed in series with the corona tube. Some of Farwell's experiments were repeated, using the same discharge tube, and his results were confirmed. One phenomenon, however, which is very pronounced and fairly regular, Farwell mentions only occasionally. If a short spark is placed in series with the corona tube, at atmospheric pressure, a few bright radial pencils or streamers of light shoot out regularly from the wire toward the tube. These streamers increase in number and in brightness as the spark-gap is opened, and may at times completely fill the tube with purple light. The same effect is obtained in a spherical glass bulb about 8 cm. in diam., one half of whose inner surface is silvered, and connected with an electrode. The other electrode is a copper ball, 3 mm. in diam., at the centre of the bulb. With nitrogen in the bulb at a pressure of about $\frac{1}{2}$ atmo. and with a p.d. of 4500 volts, the central ball when positive is covered with a very thin uniform layer of light. If, however, a small spark-gap is introduced in the circuit, more than half the bulb is filled with beautiful streamers of purple light. Similar results are obtained with hydrogen in the bulb. It was thought that the current in the corona tube, with a spark in series, might be oscillatory, but investigations by three different methods led to the conclusion that the corona current with a spark in series is only intermittent and not oscillatory.

A hot-lime-kathode Braun tube was developed and used in investigating the weak pulsating currents which occur in the corona tube with a series spark. Without a spark-gap the ordinary uniform positive glow is formed by ionisation in the gas near the wire where the field strength is greater than 30,000 volts per cm., the current being carried by both positive and negative ions. The usual negative corona discharge begins critically as a uniform glow similar to that of the positive discharge, but has a greater thickness. The brushes or negative beads soon formed by a slight potential increase bear a similarity to the arc, and from the influence which the surface condition and the material of the wires have on the beads it seems probable that an electron emission is present in addition to ionisation by collision in the gas.

The case is somewhat different with the series spark. The corona tube may be considered as a leaky condenser connected in series with a spark-gap and a constant source of high potential. A charge will build up on the condenser until the p.d. of the spark-gap is sufficient to break down the air between the electrodes. An instantaneous unidirectional current will flow across the spark-gap and at the same time the potential across the tube will increase to a point at which the corona is formed. The current now flowing through the tube will immediately reduce the potential of the spark-gap below its critical point and the circuit will be broken. The process is then repeated. The more nearly uniform

appearance of the negative corona can now be explained as a superimposed building-up and decay of the negative glow discharge through its different stages as the potential on the tube fluctuates. The positive streamers have at times been observed on rough wires when no spark was in series. These streamers are similar to the positive brush discharges observed from pointed electrodes maintained at high potentials. Their characteristic presence in the corona tube when a spark is in series is due probably to the sudden impression of a strong field, and may be accompanied by a discharge of positive metallic ions, since it has been observed that the surface of the wire becomes disintegrated at points where the streamers are maintained. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

704. *Thermoelectric Diagrams on the P-V Plane.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 4. pp. 29–35, Feb., 1918.)—The author considers a circuit of two metals α and β with junctions at temperatures T_1 and T_2. The metals may be joined by alloys at the junction temperatures and changing gradually in composition from pure α at metal α to pure β at β. The free electrons are assumed to be the only ones taking part in the production of the thermoelectric current and specific attraction of either metal for electrons does not enter into the discussion. Ordinary electrostatic attraction together with the mechanical, expansive heat-pressure of the electrons is sufficient to account for thermoelectric action in a metallic circuit. If v is the volume of 1 gm. of free electrons within a metal, G the number per gm. and p the free electron pressure, then, corresponding to the ordinary gas equation, the author writes $pv = GRT$. R may, however, be a function of T and vary from metal to metal. The cycle on the P-V diagram consists of two changes through the junctions (isothermal), and two through the metals. The slope of the latter will differ from the adiabatic according to the sign of the Thomson-effect. Two alternative hypotheses are then used, viz. that the mechanical tendency is (1) toward equality of pressure, (2) toward thermal effusion equilibrium, and it is shown that in either of these cases the net e.m.f. of the circuit is proportional to the area of the cycle. L. L.

705. *Calculation of the Maximum Force between Two Coaxial Circular Currents.* **H. Nagaoka.** (Phil. Mag. 35. pp. 13–21, Jan., 1918.)—The process used by the author is similar to that employed in his previous papers. By two or three processes of approximation in finding the value of q, it leads to results which can be used in measurements of great accuracy even in the most unfavourable case.

The bearing of this calculation upon the accuracy of the current-balance is touched upon, and the author then deals with the possibility of overcoming the delay caused by bad weather in making gravity determinations. The use of a current-balance instead of invariable pendulums is considered. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

706. *Reversible Magnetic Permeability at High Frequencies.* **F. Erhardt.** (Ann. d. Physik, 54. 1. pp. 41–60, Feb. 8, 1918.)—The full paper corresponding to Abs. 333 (1917).

707. *Horizontal Intensity Determinations with Dieterici Magnetometer.* **M. Rheinhold.** (Phys. Zeits. 19. pp. 22–23, Jan. 15, 1918.)—Experiments are detailed showing the precision obtained in determinations of horizontal intensity of the earth's magnetic field with the Dieterici magnetometer [Abs. 114 (1918)], using different periods of swing and current strength. The extreme values of H given are 0·1979 and 0·1970 gauss. C. P. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

708. *On the Molecular Physics of Ore Flotation.* **W. H. Coghill** and **C. O. Anderson.** (J. Phys. Chem. 22. pp. 237–255, April, 1918.)—The authors discuss the principles underlying the flotation of solids, and develop practical formulæ for the floating of steel and aluminium wires on water. In the case of floating galena grains they show that the mineral is wholly below the bottom of the dimple and that the liquid profile meets the upper horizontal face at 45°. A. F.

709. *Step Structure in Certain Anisotropic Liquids.* **F. Grandjean.** (Comptes Rendus, 166. pp. 165–167, Jan. 28, 1918.)—Step structure was first observed in the case of ethyl azoxybenzoate and azoxycinnamate, and is found also in the oleates and the positive phase of cholesterine caprinate. The structure is observed in liquid drops of all dimensions which rest on a plane support and have their optical axis oriented normally to the support. The free face of the drop, instead of being curved, is formed by a series of planes exactly parallel to the support, and consequently perpendicular to the optical axis. The structure is homogeneous and parallel, the optical axis having a single direction in the whole mass except in the immediate neighbourhood of the lateral surfaces or the surfaces which separate the "steps." Between crossed nicols the field of view is therefore dark, only the edges of the steps showing double refraction. The best steps are obtained with ethyl azoxycinnamate. The edges of the steps are generally marked by lines of focal groups. The steps may be of a thickness of only 0·1 μ. If the drop is deformed the steps slide one over the other without the structure being modified. This step structure reveals a discontinuous structure in a liquid, and differentiates the anisotropic liquids mentioned above from those of the group azoxyphenetole, in which no similar phenomenon has been observed. A. F.

710. *The Hardening of Chromium and Copper Steels.* **L. Grenet.** (Iron and Steel Inst., J. 95. pp. 104–117, 1917. Engineering, 104. pp. 25–26, July 6, 1917.)—Deals with the penetration of the hardening effect in chromium and copper steels and more especially with the influence of copper on the depth of hardening, particularly in the presence of chromium. Tables of analyses and mechanical tests are given, and the following is a summary of the conclusions arrived at:—Copper increases the depth of hardening effect in steels. The influence of copper in the presence of chromium is marked. One per cent. of copper suffices to confer on steels containing 1·5 % Cr an interesting degree of capacity for sustaining the hardening effect in point of depth. The action of Cu is more limited than that of Ni. The simultaneous employment of Cu, Ni, and Cr allows of semi-hard steels being prepared which can be hardened by air-cooling on large pieces and yet are softened by the ordinary annealing methods used for carbon steels.

The chief influence of copper is to increase the depth of the penetrative influence of the quenching, and it appears to have other useful effects on the properties of steel.

A note is added on the hardening of steels containing high percentages of Cr. C. O. B.

711. *Heterogeneity of Steel.* **H. le Chatelier** and **E. L. Dupuy.** (Rev. de Met. 15. pp. 127–131, March–April, 1918.)—Stead's etching reagent is

modified [see Abs. 119 (1916)]. The content in copper chloride, 1 gm., and in picric acid, 0·5 gm., may be varied; the concentration of ethyl alcohol, 100 cm.^{3} with 10 cm.^{3} of water, is essential; the correct hydrochloric acid concentration, 1·5 to 2·5 cm.^{3}, is found by trial by mixing two solutions containing respectively 1 and 3 cm.^{3} of HCl and letting them act for a period of 1 minute (maximum); with little HCl hardly any copper is deposited, with much a uniform deposit is obtained; the proper mixture gives a dull brown, non-metallic deposit, and bright patches free from Cu. When photographs are to be taken, the treated specimen is made anode for a few seconds in a bath containing 10 % of sodium bicarbonate; currents of 0·1 amp./cm.^{2} then oxidise and blacken the copper where it is dense, while dissolving it from zones where the coating is thin. So treated all steels, even with less than 0·015 % of phosphorus, appear heterogeneous. The etching is most marked in specimens quenched and reheated; but the thermal treatment does not affect the form and dimensions of the zones, the presence of Si and Mn has no influence, and the carbon distribution does not account for the heterogeneity. The copper is deposited both on pearlite and on ferrite; yet there are differences. The only conclusion so far drawn is that the parallel zones of rolled steels arise from the lengthening of the heterogeneous zones formed at the moment of the first solidification of the molten metal. Some photographs are reproduced; the magnification should not exceed 10 diameters. H. B.

712. *Heterogeneity of Steel.* **G. Charpy** and **S. Bonnerot.** (Rev. de Mét. 15. pp. 132–136, March–April, 1918.)—The authors generally use the reagent of le Chatelier [see preceding Abs.], but place the specimens treated with the reagent in ammonia which dissolves the copper from parts of an apparently uniform surface, leaving the pearlite bright and the ferrite dark; the resulting positive closely resembles the negative of a specimen etched with nitric acid or iodine. The appearance is less affected by the carbon conditions than by the other metals present; thermal treatment has little influence. The dendritic structure of the ingot becomes more and more strikingly striated when the ingot is rolled down and its length increased 150 times. In the ingot the dendrites may be 20 times larger in the centre than in the peripheral regions. The etching processes so far applied seem to reveal only part of the real heterogeneity of steel. H. B.

713. *The Metallurgy of Titanium.* **R. J. Anderson.** (Frank. Inst., J. 184. pp. 469–508, Oct.; 637–650, Nov., and pp. 885–900, Dec., 1917.)—Includes a lengthy bibliography. L. H. W.

714. *A New Process of Quantitative Analysis.* **A. B. P. Leme.** (Comptes Rendus, 166. pp. 465–467, March 18, 1918.)—Attempts to apply the spectrochemical method to quantitative analysis have generally failed owing to fractional volatilisation. The author therefore proposes the following procedure. In the Féry spectrograph employed there is a screen which covers the photographic plate. In this screen a horizontal opening is made with parallel edges. When the screen is displaced vertically in its own plane it uncovers on the plate six bands corresponding with six arrests in the movement of the screen, thus permitting six adjacent spectra to be obtained. By making the vertical motion of the screen uniform and knowing the vertical distance of movement and the width of the opening, it can be arranged that each point of the plate shall receive equal exposure in unit time. By always working under the same conditions it can be ensured that the amount of volatilisation for a given element and ray is the same, and the amount can be determined by experiment for the different elements. A. F.

715. *The Synthesis of Ammonia at High Temperatures.* **E. B. Maxted.** (Chem. Soc., J., Trans. 113. pp. 168–172, March, 1918.)—The author shows that thermodynamically the ammonia equilibrium first sinks with increasing temperature, then passes through a minimum, and finally rises again. By suddenly cooling mixtures of nitrogen and hydrogen, much of the ammonia contained therein may be obtained at the ordinary temperature, and the ammonia formed is, if we assume Féry's measurements for the temperature of the oxy-hydrogen flame to be correct, greater than corresponds with Haber's equation for the ammonia equilibrium at temperatures below 1000°. With direct cooling of flames by means of water, volumes of ammonia amounting for atmospheric pressure to 1·23 % of the mixture of nitrogen and hydrogen have been obtained. With indirect cooling, less ammonia is recovered, the max. volume per cent. obtained at atmospheric pressure being 0·21. A. F.

716. *Potential Measurements on the Copper-Nickel Series of Alloys, and some Observations on Brasses.* **N. T. Gordon** and **D. P. Smith.** (J. Phys. Chem. 22. pp. 194–215, March, 1918.)—Further experiments on the copper-zinc alloys [compare Abs. 633 (1916)] show these to be variable as regards e.m.f., and it seems probable that these irregularities may be connected with various observations of other workers which appear to indicate that the α-brasses are not so simple in conduct as would be inferred from the generally accepted equilibrium diagrams of Shepherd and of Carpenter. Copper-nickel alloys, however, are found to be very regular in their electrochemical behaviour, it being possible to obtain values for their potentials which are reproducible and constant to within 3 millivolts, and which remain constant, within the same limits, for many hours. The alloys of Cu used contained respectively 6·8, 10·9, 65·5, 74·3, 83·4, and 94·7 % of Cu; they were all carefully annealed in an atmosphere of nitrogen. The electrolytes used possessed a total normality of 1 with respect to copper sulphate and nickel sulphate combined, the compositions varying from 0·01N-$CuSO_4$ + 0·99N-$NiSO_4$ to 0·3N-$CuSO_4$ + 0·7N-$NiSO_4$. In some cases they were also normal with respect to sodium sulphate, but this merely led to a parallel displacement of the lines representing the relation between the potential and the composition of the electrolyte. All measurements were made at 25° against a normal calomel electrode. The results obtained show that the potential attained is determined jointly by the composition of the alloy and the composition of the electrolyte. The relation connecting these quantities is linear and is given by the expression $E = 573 + 0{\cdot}277x - 30{\cdot}14 \log [CuSO_4]$, where x is the percentage of copper in the alloy. If the concentration of the Cü-ion is used instead of the concentration of the copper sulphate, the equation becomes $E = 587 + 0{\cdot}4x - 37{\cdot}65 \log [Cü]$. The tendency to give ions to the solution is increased as a result of polishing the surfaces of the alloys, whilst by coarser grinding only small accidental variations are produced from the steady values found with annealed surfaces. T. S. P.

717. *Depolarisation of a Leclanché Cell.* **F. E. Hackett** and **R. J. Feely.** (Roy. Dublin Soc., Proc. 15. pp. 279–288, March, 1918.)—The author describes particularly the depolarisation curves of the Leclanché cell. For this purpose a cell was polarised by allowing it to give a constant current for a certain time. The fall of voltage was noted, and the recovery was observed. Although the curves of falling voltage varied somewhat, those of recovery were always found to be the same. Thus recovery may be

divided into two sections, the first of which is characterised by a rapid rise, and the second by a slow creeping rise. The p.d. due to a change in concentration in electrolyte is small, and might account for the creep in voltage. The part which shows rapid recovery must be due to a surplus of ions over those required for equilibrium. The conditions existing resemble those in an ionised gas close to an electrode; it thus seems that depolarisation might follow a relation such as: $\partial P/\partial t = -aP^2$. Here, the expression P would be taken as that part of the polarisation which is due to the excess of ions, and is associated with the rapid recovery. This relation leads to the following: $(V_s - V)^{-1} = at + (V_s - V_0)^{-1}$, in which V_0 = initial e.m.f. at the instant of opening the circuit; V = e.m.f. of cell at any subsequent time; V_s = quasi-stationary value of e.m.f. and $P = V_s - V$. The results obtained were found to give a satisfactory relation of this kind. Experiments were also made with a Weston standard cell, and the conclusion reached was that in this case no correction was necessary for a slow rise, the recovery being governed by a single process. W. R. C.

718. *Electrolytic Behaviour of Tungsten.* **W. E. Koerner.** (Am. Electrochem. Soc., Trans. 31. pp. 221–247; Disc., 247–255, 1917. Met. and Chem. Eng. 16. pp. 40–47, Jan., 1917.)—Measurements of the single potentials of tungsten in normal solutions of various acids, alkalies, and neutral salts give the following results. In each case the compounds are mentioned in the order of increasing potential of the tungsten electrode. *Acids*: H_2SO_4, HCl, HNO_3. The potential in nitric acid corresponds with that of copper in a solution of cupric chloride which is normal with respect to Cu ions. *Alkalies*: KCN, KOH or NaOH, NH_4OH. The potential in KOH (or NaOH) solution corresponds with that of thallium in a thallium chloride solution, which is normal with respect to Tl-ions. *Neutral salts*: KNO_3, KF, KBr, KCl, K_2SO_4, KI. With respect to the above three classes the order of potential is: alkalies, acids, neutral salts. A number of chemical facts in connection with the behaviour of tungstic acid are given, and it is shown that tungsten dissolves anodically in aqueous and non-aqueous solutions of alkalies, acids, and salts; in the case of solutions of alkalies the anode becomes passive only at very high current densities, whereas in acid and salt solutions passivification takes place even at low current densities. The passivity is shown to be due to adjacent films of hydrated tungsten oxides, and the phenomena observed are explicable by the oxide theories of passivity. The electrochemical equivalent of tungsten was found to be 0·3173 mg. per coulomb, a value corresponding very closely with the theoretical.

Experiments on the use of tungsten in voltaic, standard, and storage cells are described; the experiments are only preliminary ones and are to be extended; fuller details and discussion will be given in a later paper.

T. S. P.

719. *Essential Oils as Addition Agents in Plating Baths.* **F. C. Mathers** and **A. B. Leible.** (Am. Electrochem. Soc., Trans. 31. pp. 271–282; Disc., 282–284, 1917.)—Squares of sheet metal were shaken with aqueous solutions of the various essential oils (eugenol, carvol, pine needle, bay, citronella, fennel, peppermint, bergamot, thymol, red thyme, clove, and cumol), and the amounts adsorbed determined by difference by analysis of the residual solutions. Every metal used adsorbed every oil to a certain extent, and the more readily an oil is adsorbed the greater its effect as an addition agent; the mere adsorption of an oil by a metal, however, proves nothing concerning the value of the oil as an addition agent. The arrangement of the oils in

the order of decreasing adsorption is nearly the same for many of the metals and a similarity exists in the cases of the others. The metals arranged in respect to decreasing adsorption of the oils are : Pb, Sb, Cu, Cd, Zn, Fe, Sn, and Ag. An arrangement of these metals as regards increasing difficulty in preventing rough crystalline deposits by the use of addition agents would agree in most cases with this order. Copper should probably come first and antimony second. These conclusions only hold in a general way. Tin and silver adsorb the oils, but are influenced very little by these oils in plating baths. Antimony adsorbs thymol in smaller quantity than tin and silver adsorb certain other oils, yet antimony is very much influenced by thymol.

T. S. P.

720. *Tests of Antimony Plating Baths.* **F. C. Mathers** and **K. S. Means.** (Am. Electrochem. Soc., Trans. 31. pp. 289–291, 1917.)—The deposition of antimony from numerous electrolytes was tried, such as the tartrate, chloride, oxalate, and fluoride, with the addition of glue, peptone, aloin, etc., as addition agents. The most satisfactory bath is the fluoride [see next Abs.], containing free hydrofluoric acid and a small amount of aloin, resorcinol, α- or β-naphthol, or salicylic acid. T. S. P.

721. *Electro-deposition of Antimony from Fluoride Baths containing Addition Agents.* **F. C. Mathers, K. S. Means,** and **B. F. Richard.** (Am. Electrochem. Soc., Trans. 31. pp. 293–301 ; Disc., 301–302, 1917.)—Antimony fluoride and free hydrofluoric acid give the best bath for the electro-deposition of antimony. The bath recommended contains 5 % of Sb as the fluoride and 3 % of free hydrofluoric acid, and a suitable addition agent must be used to prevent a crystalline structure. These baths work easily and without any indication of deterioration or undesirable change, if the proper quantity of addition agent is maintained and if the ordinary precautions in plating are preserved. Without the organic addition agents the deposits are rough and crystalline. The smoothest, thickest, and least crystalline deposits were obtained by adding aloin, β-naphthol, α-naphthol, or resorcinol ; sufficient addition agent to give a strength of 0·025 % must be added every 12 hours during the electrolysis. The deposits are grey and finely crystalline ; too large a quantity of some of the addition agents makes the deposits darker and more glossy. This latter result can also be produced by adding very small amounts of clove oil (0·0012 cm.^{3}) along with any other of the addition agents. The deposits are brittle, like ordinary cast antimony, so that if a plated article is bent the deposit will crack. Aloin is the cheapest of the satisfactory addition agents. Excess of almost any of the addition agents causes the deposits to crack. Essential oils, such as clove, thymol, etc., had such a large effect that it was impossible to maintain the correct quantity in the baths. Glue gives good results, but not so good as aloin. Antimony seems to be the best metal to use in testing out theories of addition agents, because it is the most sensitive. The presence of an aromatic hydroxyl or carboxyl group in the addition agent seems to be a necessary factor. T. S. P.

722. *Evolution of Hydrogen from Cyanide Plating Solutions.* **O. P. Watts** and **A. Brann.** (Am. Electrochem. Soc., Trans. 31. pp. 303–308 ; Disc., 308–310, 1917.)—Experiments were made with silver and copper cyanide solutions, with the addition of varying amounts of free KCN, to determine the effect of the latter in producing liberation of hydrogen at the kathode. It was found that the great lowering of the current efficiency of copper and

brass plating solutions caused by the addition of considerable amounts of sodium or potassium cyanide is due to the elevation of the potential of the metal which is being deposited, until it equals and finally exceeds, the discharge potential of hydrogen, so that this gas is deposited instead of metal. The solvent action of cyanide on the deposit is comparatively unimportant. The addition of free cyanide to the silver bath does not produce the marked lowering of efficiency observed in copper and brass solutions. This is due to the fact that the rise of potential of silver with increase of free cyanide is less marked than for copper and brass. Even the addition of 60 gm. of free cyanide per litre leaves the potential of silver considerably below the discharge potential of hydrogen, instead of above this as in the case of brass and copper. T. S. P.

723. *Alternating-current Electrolysis with Mercury Electrodes.* **H. B. Weiser.** (J. Phys. Chem. 22. pp. 77–94, Feb., 1918.)—A critical revision of the work hitherto done on the electrolytic corrosion of solid metallic electrodes shows that the efficiency of the process varies so widely with minor differences in the electrode surface that the results of a given set of experiments cannot be reproduced. When mercury electrodes are used, however, the surface of the mercury, under the influence of an alternating current, undergoes rhythmical vibrations or pulsations, since the surface tension of the mercury varies with its electrical charge. These vibrations keep the electrode surface perfectly clean and also keep the solution agitated in the neighbourhood of the electrodes. Under these conditions, using a solution of sodium thiosulphate as the electrolyte, and an alternating current of 60 cycles (7200 alternations per min.), the experimental results are reproducible with ease and accuracy. The majority of the experiments were carried out at 100° and it was found that the efficiency of corrosion increases almost directly with the concentration (5–35 %) of the thiosulphate solution. With very high concentrations (50 %), however, a film of mercuric sulphide forms over the surface of the electrode, and this diminishes the corrosion very considerably. The efficiency of corrosion is increased by mechanical stirring, decreased by fall in temperature, and increased, although not proportionally, by increase in current density; in this last case the variation from strict proportionality is greater in dilute than in concentrated solution. Any variation in conditions that affects the concentration of the electrolyte in the immediate region of the electrodes correspondingly affects the efficiency of corrosion.

Under similar conditions zinc electrodes corrode much less readily with the alternating current than do mercury electrodes. The effect on the efficiency of corrosion produced by variations in current density, stirring, temperature, and concentration of the thiosulphate solution is of the same character with solid metallic electrodes as with mercury, but with the former these effects are negligibly small compared with that resulting from slight differences in the electrode surface. T. S. P.